TAMPERE UNIVERSITY OF TECHNOLOGY
Degree Programme in Information Technology

SARVANI SAMMETLA
MOBILE LOCATION BASED SERVICES FOR MOUNTAINEERING
Master of Science Thesis

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Examiners and topic approved
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ABSTRACT

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Smart phones are widely accepted and popular with navigation and route guidance functionality becoming a standard feature. Locations based services, henceforth referred to as LBS in this document, are used in various contexts and are becoming more accessible with the wide adoption of mobile smart phones. Industry experts expect that Location based services to be a major success and will account for large market share and profits in mobile services. Service providers in this area are coming up with innovative services trying to grab a share in this potential area. On the other hand, there is also some pessimism on the pace at which LBS taking-off in practice due to various reasons. For any service or business to be successful it should create value to the end-users. There are many key players involved to make LBS realizable and providing value, which include technology providers, service providers, telecom companies, regulation and standardization bodies and end-users.

This thesis is a literature review of LBS and its general applications in real world with emphasis on its use in mountaineering. Scope of this literature review is to study the components of LBS, its architecture, positioning techniques, general application area, established standards and potential business model. While emphasizing LBS use in mountaineering, a concluded LBS demo project for mountaineering, sponsored by European Commission, called PARAMOUNT (Public Safety & Commercial Info-Mobility Applications & Services in the Mountains) is taken as reference. From business perspective, a conceptual business model called STOF (Service, Technology, Organization and Finance) model is used to analyze PARAMOUNT.

PREFACE

This master thesis has been prepared during the period of January 2011 –November 2011 at the Department of Computer Systems, Tampere University of Technology, Finland.

I sincerely thank and express my deep gratitude to my supervisor Helena Leppäkoski, for her valuable advice, patient guidance and for lending me a lot of useful materials.

I am grateful to my lovely daughter for co-operating with me while I was busy working on the thesis. Finally, I am indebted to my parents and my sister for their constant encouragement and support.

Sarvani

ABBREVIATIONS AND KEY WORDS

3GPP	Third Generation Partnership Project
A-GPS	Assisted Global Positioning System
ADT	Abstract data type
AOA	Angle of Arrival
AOI	Area of interest
API	Application Program Interface
BTS	Base transceiver station
CI	Cell Identity
DV	Delivered Value
E911	Enhanced 911
EMAIL	Electronic Mail
EOTD	Estimated Observed Time Difference
ESA	European Space Agency
EV	Expected value
FIP's	Fair Information Practices
FCC	Federal Communication Commission
GIS	Geographic Information Systems
GPS	Global positioning system
GLONASS	Radio-based satellite navigation system operated for the Russian government by the Russian Space Forces.
GML	Geographical markup language
GNSS	Global navigation satellite system
GPRS	General Packet radio service
GSM	Global System for Mobile Communications
GTD	Geometric time difference
IETF	Internet Engineering Task Force
IN	Instant Messaging
ISP	Internet Service Portal
IV	Intended Value
LBA	Location Based Advertisement
LBS	Location based services
LMU	Location measurement unit
MIN	Minimum
MMS	Multimedia Messaging Service
MOD	Moving object database
MS	Mobile Station
NICTS	New Information and Communication Technologies
OMA	Open Mobile Alliance
OGC	Open Geospatial Consortium

Open LS	Open Location Services
OTDOA	Observed Time Difference on Arrival
OTD	Observed Time Difference
PARAMOUNT	Public Safety & Commercial Info-Mobility Applications & Services in the Mountains
PDE	Position Determination Equipment
PDA	Personal Digital Assistant
PET's	Privacy Enhancing Technologies
PV	Perceived Value
POI's	Point of Interests
PSAP	Public safety answering point
QOS	Quality of Service
RTD	Real Time Difference
SIM	subscriber identity module
SMS	Short Message Service
STOF	Service, technology, organization and Finance
TA	Time of Arrival
US	United States
WAP	Wireless Application Protocol
WDM	Web data manager
WLAN	Wireless Local Area Network
WIFI	Wireless Fidelity
XML	Extended markup language
ZOI	Zone of Interest

Contents

1. INTRODUCTION

Mobile phones and Internet have revolutionized the communication and lifestyle of the people across the world. With this revolution there are many people who want to access data through mobile phones and personal digital assistants (PDA's) wherever they are. The field of location based services (LBS) emerged a few years ago, but the technology got boost really in late 1990's when GPS capabilities started to appear in mobile devices such as cell phones. The wide adoption of mobile devices along with United States federal enhanced emergency services requirements and the ubiquity of GPS capabilities in mobile devices have spurred the development of mobile location technologies known as location based services (LBS). Location Based Services can be seen as an intersection of three technologies: New Information and Communication Technologies (NICTS) which includes the mobile telecommunication system and handheld devices, Internet and geographic information systems (GIS) as shown in Figure 1.1. [37]. Teliasonera in Sweden and EMT in Estonia launched first LBS services; however the first commercial LBS service was in Japan launched by DOCOMO. Location information describes a physical position or attributes of a place and privacy status. Many applications benefit from using the location information and many companies have come up with new service concepts like tracking, navigation, fleet management, friend finder applications and so forth [9].

Location based services can be used in various fields for example health, work and personal life. Location based services can be query based known as pull type services, provides the user with information such as the nearest restaurant, nearest ATM and help users to find location information in an unknown places. At the same time mobile advertisements or marketing information can be sent to customers who are in a specific geographical area, which are push kind of services, so the user knows the information in his surroundings with the advertisements. The example devices needed for these LBS to be viewed are shown in the Figure 1.2. According to [1], location based services have been advertised and promoted as “killer services” for third generation telecom networks. However, there is a slow take-off of LBS market as there are lot of differences among offered services, customer’s perception, service providers, tentative attitude against LBS, technological limitations, privacy concerns of the customers and standardization issues.

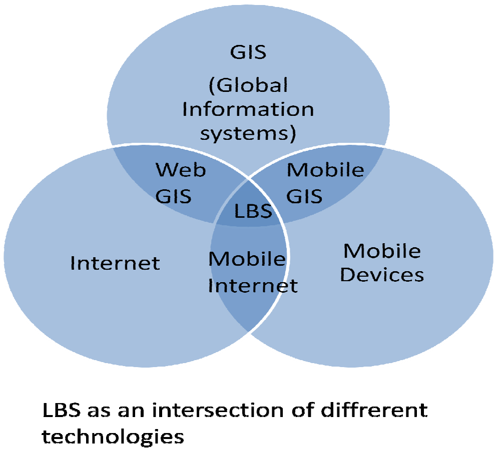

***Figure 1.1**. LBS as an intersection of different technologies (Adapted from [31])*

Mountaineering or mountain climbing is a sport or hobby or profession, an attempt to reach highest point of the unclimbed mountains. Mountaineering is also known as Mountain Alpinism. The main areas of mountaineering are: Rock-Craft or Rock Climbing, Snow-Craft or Snow Climbing and Skiing\Ice Route. Rock crafting involves rocky slopes or rocky route and avalanches, whereas Snow climbing is for more expert climbers and the most difficult one is the skiing, this involves both rocky and Icy routes. Mountaineering sport challenges the individual capabilities and skills and usually mountaineers find climbing as a form of relaxation and exercise and this is a popular sport throughout the world. Below in this documents we look at LBS application in mountaineering.

1.1 Goals and structure

The goal of this literature review is to understand the technology involved with location based services including its architecture, positioning techniques and its application in the real life with special emphasis on its use in mountaineering. This report will also analyze demo project called PARAMOUNT, sponsored by European Commission, which provides location based services in mountaineering.

Figure 1.2. *Different Mobile devices for realizing LBS (Adapted from [31])*

Chapter 1 is general introduction to location based services. It explains the history of LBS, how the thesis is arranged in six chapters. The goals for this thesis are also explained in this chapter.

Chapter 2 is arranged to explain the overview of the location based services. It explains the general concepts which include the necessary components for successful LBS, different positioning techniques and technologies and architectural details of LBS.

Chapter 3 explains different LBS applications and different standards which currently exist to support Location Based services.

Chapter 4 is dedicated to explain the importance of privacy, research model which describes and relates various parameters to privacy. The concepts of location privacy and architectures needed to ensure privacy.

Chapter 5 is dedicated to explain the STOF (service, Technology, organization, finance) business model proposed by Bouwman [4]. The various design parameters in each domain are studied and the critical design issues in each domain are studied

Chapter 6 is arranged to explain LBS use in mountaineering by taking a demo project called PARAMOUNT service into consideration. These services are explained with the critical design issues identified in the previous chapter.

Chapter 7 is conclusions. This will explain the key findings of this thesis.

2. FOUNDATIONS OF LOCATION BASED SERVICES

Determining the geographic location is one of the key factors for Location based services (LBS). Geographic location can be usually determined with co-ordinates called latitude, longitude and altitude. Virrantaus et al. defined LBS as follows [35]:
"The location-based services are the services, utilizing the ability to dynamically determine and transmit the location of persons within a mobile network by the means of their terminals".

According to Open Geospatial Consortium (OGC) LBS are defined as follows [23]:
"A wireless-IP service that uses geographic information to serve a mobile user and service that exploits the position of a mobile terminal".

2.1 Classification of LBS

Analysts and researchers took various approaches to classify LBS applications. They are mainly classified as below [29]:
Person oriented LBS Service: The main idea of this kind of service is to position a person or use the position of a person to enhance the service. Usually the person located can control the service. The best example for this application is friend finder application.
Device oriented LBS Service: In this kind of service the person or object located will not control the service. These kinds of services are external to the users and they may or may not concentrate on the position of the user. Instead of a person, a group of People or an object can be located. The best example for this kind of service is car tracking in case of theft.
According to [13], there are two methods to access these services,
Push based services: Push services are services when information is sent to the user proactively on the basis of a prior consent of the user that they want such a type of information.
Pull based services: Pull services are services initiated by users themselves entering into a specific information area.
For example: user initiated request for nearest restaurant in a particular area is a pull based request whereas, a message advertisements popping up on the users handset is a push based service.

2.2 LBS Components

According to [2], the main components of LBS are: GPS or positioning component, mobile user, telecommunication network, service and data content provider. The user uses the mobile device, in this case the mobile device can be personal digital assistant (PDA), laptop or a mobile phone to access the location based services. The mobile device is mainly used as an interface to access the services. With the help of the positioning component like GPS, the current position of the user is determined or the user can also enter his current position manually to the device. The requests from the user and service provider are usually exchanged with the help of the communication network. The service providers can offer services like providing the location information, providing the best route, searching the yellow pages to find the information like nearest ATM, hospitals, services and so forth. Usually the service providers do not store all the information and need to access data from maintaining authorities. The maintaining authorities can be geographic database, traffic control authorities, and yellow pages to retrieve the requests of the users. The relationship between the components and also the communication between them and how the information or data are exchanged among different components of location based services is shown in Figure 2.1.

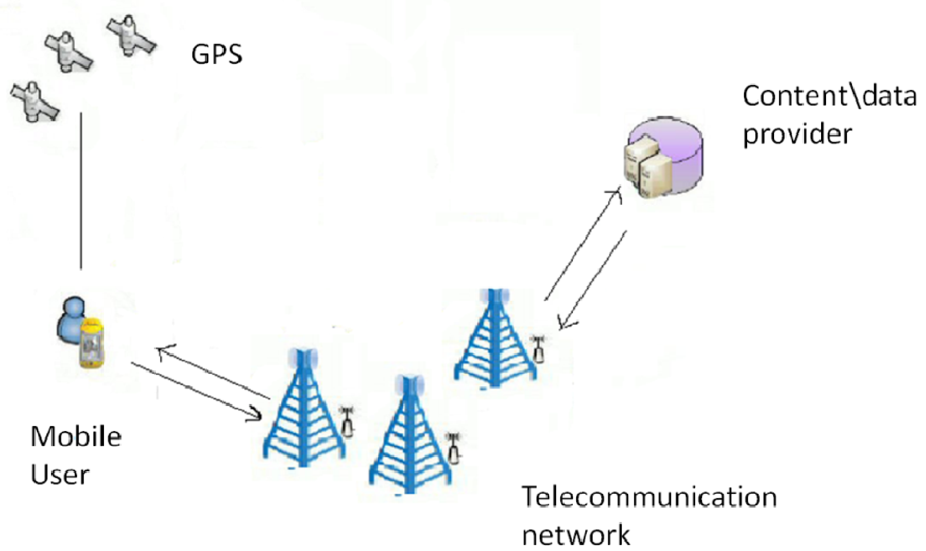

Figure 2.1. *Components of LBS (Adapted from [2])*

2.3 LBS Architecture

Location based services architecture is described by a 3-tiered communication model as shown in Figure 2.2, with a database called geographic information system (GIS), used to store location related information and location based logic [29]. GIS is a database to store, manipulate, analyze, manage, and present all types of geographically referenced data.

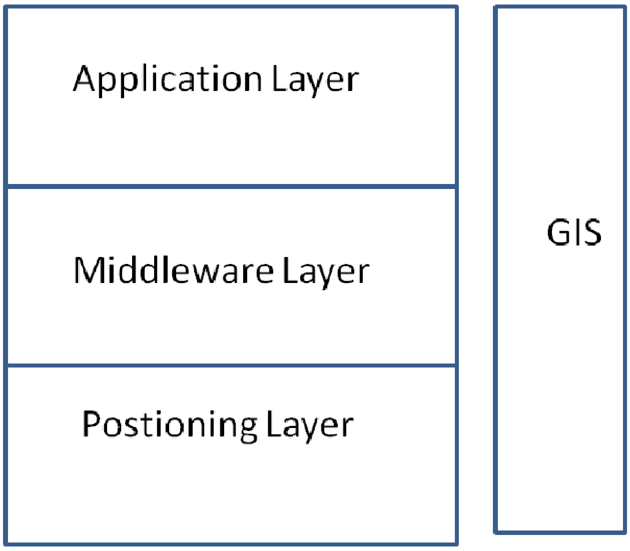

Figure 2.2. *Architecture of LBS (Adapted from [29])*

2.3.1 Positioning Layer

In this layer location data is processed. This layer is responsible for calculating the position of a mobile device or user. This is achieved with the position determination equipment (PDE) and geospatial data held in GIS. PDE calculates where a device is in network terms, the GIS allows it to translate this information into geographic information (longitudes and latitudes).The end result is passed through the location gateway directly to the middleware platform [29].

2.3.2 Middleware Layer

According to [6, 13, 29 and 37], this layer acts as a bridge between the positioning layer and the application layer. This layer needs to be carefully designed so that it would support future system enhancements and is either deployed within the network operator's network or hosted by an application service provider. Many different middleware architectures exist in the market, without one dominant player at this point in sight. To realize a location based service a number of different players have to be involved. This includes hardware and software vendors, content and online service providers, wireless network and infrastructure providers, wireless handset vendors and branded portal sites. To ensure that all the different technologies and devices work together common standards for interfaces and description have to be defined. Open Geospatial Consortium, a standardization body released a specification for LBS middleware known as Open location services (Open LS). This section deals with two different middleware architectures, one of them uses open location services (Open LS) standard in designing the middleware, and the other known as Publish/Subscribe Middleware model. The architecture of the proposed middleware using Open LS standard is shown in Figure 2.3. It mainly includes five groups of components core services: location server, location-relative Data

Support, Service Platform, Application Program Interfaces. The functions of these components are introduced below.

Open LS defines core services, their access and abstract data types which form together a framework for open service platform, called Geo-Mobility server. Core services include directory service, geo-code service, reverse geo-code service, route service, gateway service and presentation service. Directory service provides subscribers with access to an online directory to find the nearest place, specific place, product or service. Geo-code service determines a geographic position, if a place name, street address or postal code is given. Reverse geo-code service determines a complete, normalized place name/street address/postal code, for a given geographic position. Route service determines a route for a subscriber given the start point and endpoint, the subscriber may optionally specify waypoints and route preference (for example fastest, shortest, least traffic and most scenic). Gateway service is the interface between the geo-mobility server and the positioning layer and it is useful to request for the current location of the user from positioning layer. Presentation Service is used for portrayal of maps and map overlays like point of interest, area of interest, location, position and address. Besides implementing these core services in the middleware, there is also moving objects query service (MO Query) and location based events query service (Event Query) modules. Moving object queries examples include finding the location of an object at a given time, finding k-nearest taxis for a traveler (query could be how many cars are there in a specific area respectively). Events query module supports location-relative events query service, retrieves historical, current or future events related to a specific location. For example, a query "tell me which movies will be shown tonight in IMAX" can be answered by this service.

Application Programming Interface (API) layer defines access methods to the core services. The interfaces of core services are specified in extended markup language (XML) and ADT's are used for specifying XML elements. ADT is the basic information construct used by the geo-mobility server and associated core services. The ADT's used in Open LS specification are address ADT, area of interest (AOI) ADT, location ADT, map ADT, point of interest (POI) ADT and position ADT respectively. Address ADT contains address information for a geographic place with a fixed position that may be used as a reference point or as a target. AOI ADT is used as a search parameter or can be displayed for a subscriber. Position ADT contains calculated position and quality of position. The POI is the primary output from a directory service, and thus, is also the place where one might obtain service. The location ADT is used to specify the location of a target or a subscriber, serves as a placeholder for the other ADTs like position, address, POI and AOI ADT's. Map ADT contains URL address where the data of the map can be found, it provides elements for describing the properties of a map for example, resolution, height, width and centre point. An application requesting the core services sends XML request to the core service module, upon invocation of the request, process the request and the encoded XML response is sent to the invoking application.

The service platform hosts various supporting functions to support personalization, authentication, privacy protection and billing. Privacy module allows users to decide who can see their location, when, and how precisely one can see user location. Billing module gives operators a flexible set of billing options for their location and GPS services, for example, mobile operators can choose to bill per location fix, per map rendered and per route. Authentication module deals with mobile device requests for an access to application, responsible for sending authentication information to the issuing authority, depending on the credentials presented by the LBS mobile device, the issuing authority can then send a positive or negative authentication assertion.

Location data module contains three key components including a geographic information system (GIS), a moving object database (MOD) and a web data manager (WDM). The GIS maintains the static information that can be reused, including the geographic infrastructure itself. The MOD manages the dynamic location information of moving object for example, a mobile user or a running car, WDM is built in middleware to extract information from world wide web (large information source for location-based services), location relative data about specific subjects or user requested subjects are extracted and organized to support location based applications. The main functions of location server are obtaining the location information of target objects, modeling the location information and putting the location data into MOD.

Upon invocation of request from the application, core service performs the operations with the help of the other modules (service platform, location data support module, location server) respectively and the result is XML encoded and passed to the invoking component. Every request or response is encoded in extended markup language (XML) for location services as shown in Figure 2.4.

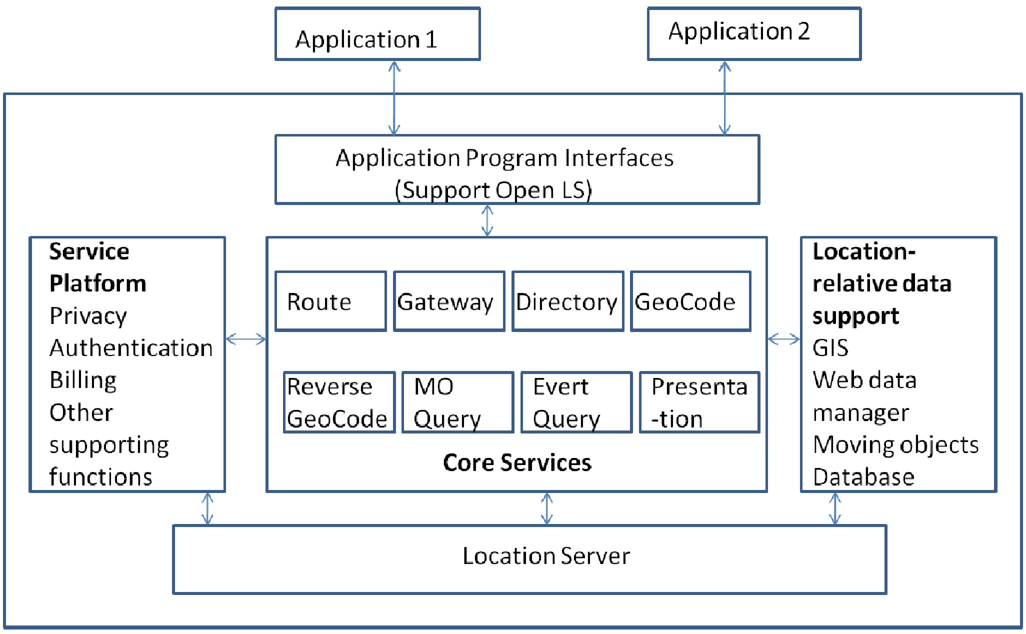

Figure 2.3. *Middleware Architecture (Adapted from [37])*

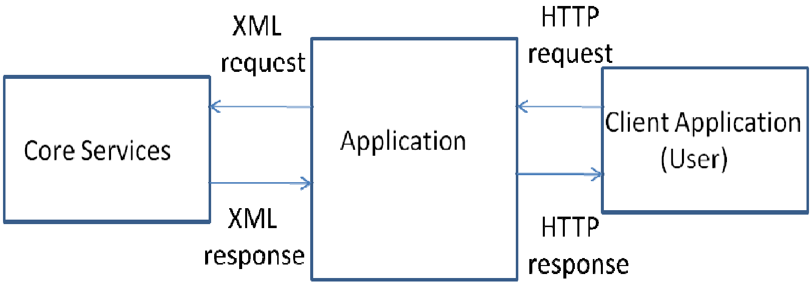

Figure 2.4. *Information Exchange in LBS middleware (Adapted from [37])*

Publish/Subscribe Middleware model

Publish/subscribe is a middleware, where publishers publish the information also called the events and the consumers subscribe to specific events they are interested in. The publishers and the subscribers are autonomous components and exchange information by publishing and subscribing the events. The central component of this architecture is the event broker. When a publisher publishes an event, the event manager who is responsible for recording all the subscriptions, asks the matcher to match it against the subscriptions. If the event satisfies against the subscriptions then notifications are sent to the subscribers. The router is responsible for finding the best path for delivering matched information to the subscriber by minimal cost and time. The role of event broker and the architecture of publish\subscribe are explained in Figure 2.5.

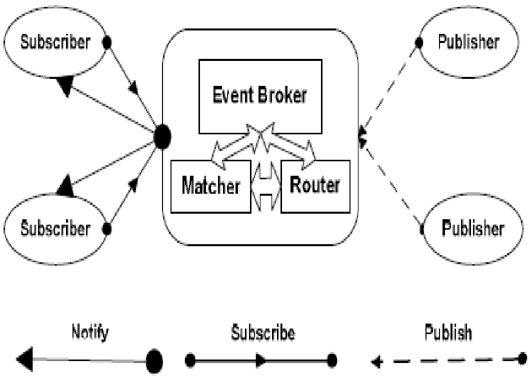

Figure 2.5. *Event Broker in publish and subscribe middleware (Adapted from [6])*

This model ensures that there is timely delivery of the information to all the interested subscribers when they enter into the zone of interest (ZOI). This model should render good quality of service (QOS), if any mistakes happen the user will not get the information requested or they may get much later.

This model has five characteristics:

Asynchronous	Information providers and consumers operate asynchronously through event broker.

Multipoint	The publications are sent to all interested subscribers.
Anonymous	The publisher need not know the identity of the subscribers.
Implicit	The set of event recipients is determined by the subscriptions.
Stateless	The events don't persist in the system rather the events are sent only to those components that have subscribed before the event was published.

Publish/subscribe middleware models have appeared to meet some emerging mobile application requirements, they support push based LBS applications and cannot cover all the LBS application scenarios. The novel framework of LBS middleware developed using open location services (Open LS), deals with modeling, querying of location data and privacy, also involves a Web data extraction module, using this module, applications can easily get some historical or instant location-relative information from the Web without collecting and maintaining everything by themselves. The main advantage of the open LS middleware is that API's are exposed so that a service provider can efficiently and effectively develop and deploy innovative LBS applications.

2.4 Positioning Techniques

Most LBS need position information of a mobile device to serve the users. The position of a mobile device is obtained using a positioning technology or the user can enter the input of his\her position manually. According to [20], the main positioning technologies used in LBS are satellite based positioning; network based positioning and local positioning methods.

2.4.1 Satellite Positioning

According to [34], GPS is a space based global navigation satellite system (GNSS) that is designed to show the exact position on the earth at anytime. A satellite motion is described by its orbit, which is a regular, repeating path around the earth followed by the satellite in certain periods of time. A constellation of satellites describes the number and positions of satellites in space. The operational GPS constellation consists of 24 satellites, which circulate the earth on six orbits with four satellites per orbit. Initially, GPS was conceived for military purposes, but the U.S. Government decided in the 1980s to make the positioning data freely available to other industries worldwide, since then many industries have benefitted to access the position data through GPS and enhance their services. Because of the freely accessible monopoly for positioning data, the European Union decided in 2002 to build comparable Satellites called GALILEO. This is a joint initiative of European Commission and European Space Agency (ESA), which is expected to be operational from 2014. US developed GPS, Europe is developing GALILEO and GLONASS was developed by Russia [27]. It is considered that together with GPS and GALILEO will have more accuracy in providing the positioning services. There will be 30 satellites in spacecraft with 3 spare ones for the upcoming GALILEO. Currently only GPS and GLONASS are operational and being used worldwide to provide positioning information. The principle of GPS uses the concept of trilateration is explained below.

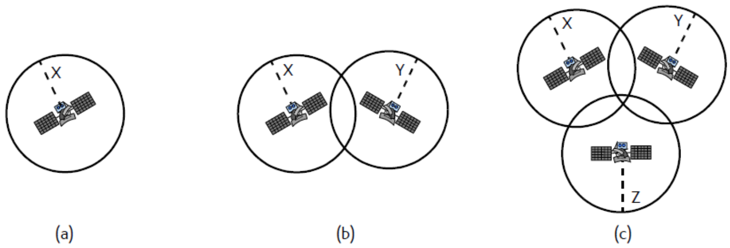

Figure 2.6. *GPS position computation for three satellites (Adapted from [8])*

The basic principle behind GPS is that a receiver measures the travel time of the signal sent from the GPS satellite to the receiver. From the measured time, the receiver can compute the distance from receiver to the satellite “X”. The receiver lies on the sphere centered on the satellite with radius “X” as shown in Figure 2.6a. The distance “Y” to a second satellite is then measured, narrowing the potential locations of the receiver as the intersection of the two spheres shown in Figure 2.6b. By taking the distance “Z” to the third satellite the potential locations of the receiver can be reduced further to just two possible points as shown in Figure 2.6c. One of these positions is then disregarded due to it being either too far from the Earth’s surface and the GPS receiver has the ability to distinguish the actual or reasonable co-ordinates. By taking readings from a fourth satellite, the receiver can be positioned in three dimensions latitude, longitude and altitude respectively. In satellite based positioning the reference stations are the satellites of the GPS, GLONASS or European Galileo Satellite Navigation System.

According to [5, 8], although the satellite positioning provides good performance, it still suffers from many environment-related issues. Because the satellites are in a high orbit, and to broadcast over a large area results in a very weak signal. Because of the weak signal, the receiver is unable to collect navigation data, the result being GPS receivers are unable to obtain a position fix inside buildings, under cover of trees or between the tall buildings which is called as urban canyon.

Standard GPS performance cannot satisfy demands of modern LBS applications. In order to meet the above requirements Assisted GPS (A-GPS) is introduced. A-GPS significantly improves the satellite positioning performance. There are three classes for positioning accuracy: Low level, standard level and high level accuracy services as depicted in the Figure 2.7. Conventional GPS satellite positioning offers results that meet all the low-level and most requirements of standard LBS. High level services require more precise information about the user's position (examples of applications which need higher positioning accuracy are dispatch, driving directions and billing). In order to meet the higher demands, assistance can be used to standard GPS positioning. With the help of assistance given to GPS, allows GPS receiver to perform faster calculation of user's position. Therefore A-GPS concept can be used to improve LBS and also customer satisfaction [29].

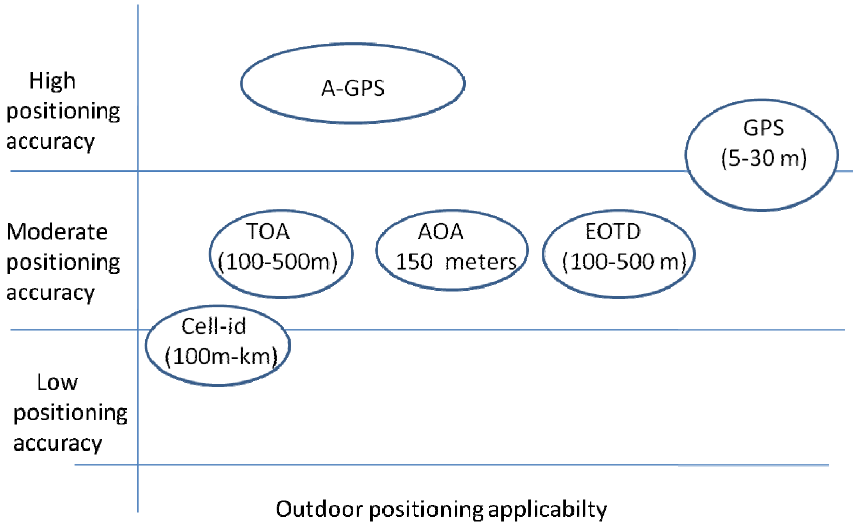

Figure 2.7. *Positioning accuracy of different positioning technologies (Adapted from [29]*

2.4.2. Network based positioning

The network based positioning is also called as cellular network based positioning. The advantage of cellular positioning over GPS is that the signal is much stronger and therefore will operate indoors and is unaffected by the urban canyon effect [8]. The typical techniques used for the Network based Positioning are Cell-Id, Enhanced-observed time difference (E-OTD), Observed time difference of Arrival (OTDOA) and Angle of Arrival (AOA).

Cell Id: The cellular network consists of cells, which cover certain areas. For each terminal, the network knows within which cell area, the terminal is. The cell size has a great effect on the location accuracy. In urban areas the cell size can be few hundred meters, whereas in rural areas it can be tens of kilometers. Each base station will have multiple antennas, each covering a sector of the cell. So, a BTS (Base transceiver station) with three antennas will produce a cell with three 120 degrees sectors. By detecting the antenna with which the mobile is registered, the location of the mobile can be narrowed somewhere within a sector of the cell [8].

Enhanced-observed time difference (E-OTD): According to [7, 8], E-OTD uses tri-lateration between BTSs to provide a location fix. This method measures the time intervals of the signals between a base station and the mobile device and a known fixed spot called Location Measurement Unit (LMU). The Figure 2.8 shows the E-OTD positioning use trilateration for postion fix is dependent on LMU's. The mobile device calculates the time difference of arrival of signals from two different base stations and these observations are known as Observed Time Difference (OTD). The mobile device measures the OTD between a number of different base stations. The transmission of signals from base stations are not synchronized in the GSM network and therefore LMU's which are located at predetermined position in the network are used for measuring the transmission time offsets between base stations. These observations are called real time difference (RTD). The RTD for two base stations can then be subtracted from the OTD for the same two base stations to produce the geometric time difference (GTD), which is the time difference that would have been measured by the mobile if the network was perfectly synchronized. For a synchronized network the RTD value is equal to Zero.

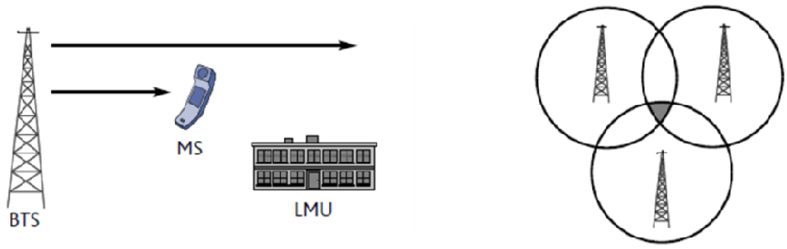

Figure 2.8. *E-OTD positioning method (Adapted from [8])*

Observed time difference of Arrival (OTDOA): According to [28, 37], in this method, the terminal measures the time differences of the signals sent by multiple base stations. For each base station pair, the measured time difference defines a hyperbola on which the terminal must lie. Thus for three base stations, two such hyperbolas can be formed, and the two dimensional location of the terminal is in the intersection of these hyperbolas. Naturally adding more base stations and hyperbolas will make the location measurement more accurate.

Angle of Arrival (AOA): According to [28], in angle of arrival (AOA) positioning the angle of arrival of the signal emitted from the terminal is measured by two or more base stations. By knowing the base station locations, the position of the mobile is found from the point of intersection of the straight lines defined by the angles of arrival.

2.4.3 Hybrid Positioning

According to [20], the bottom line is, technologies can be implemented together to have their advantages for the future requirements of LBS and to ensure high quality service to the customers**.** Satellite based positioning provides the best accuracy (up-to an average of 5 meters), but at the same time, does not work well in case of indoor positioning. GPS technology implementation needs additional infrastructure from the operator side and from the user side to have a GPS enabled handset. Network positioning methods do not need any additional infrastructure or special handsets, but accuracy is varied and depends on the coverage area, smaller cell size provides better accuracy in network-based methods. None of the previous positioning methods alone will give satisfactory results in all possible scenarios Therefore hybrid positioning, which is a combination of two or more location methods, has good advantages. A combination of assisted GPS and network positioning would combine the strengths of both methods.

3. LBS APPLICATIONS AND STANDARDS

3.1 LBS Applications

There exists a wide range of different location based services. With the popularity of the positioning in mobile phones makes it possible for new location based services and applications. Figure 3.1 shows some of the major areas of application of LBS. However the list is not complete, I have considered only few important applications and studied in this work.

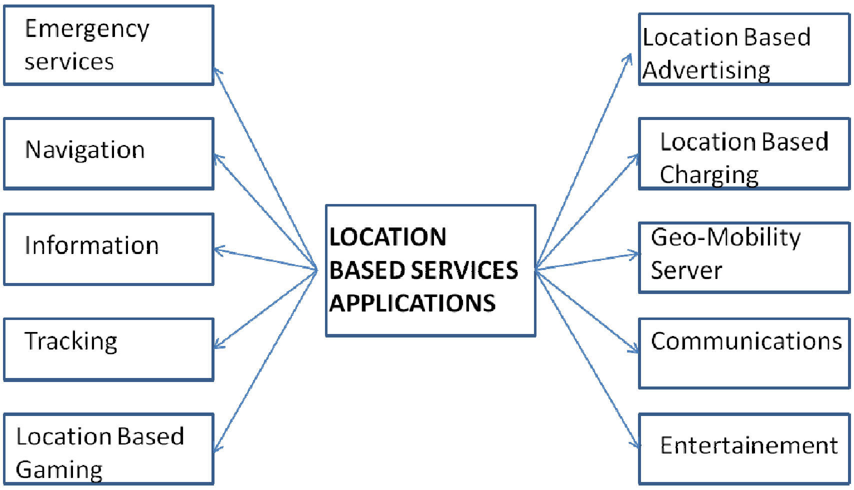

Figure 3.1 *Location Based Services Applications (Adapted from [31])*

3.1.1 Emergency Services

One of the most important and evident application of LBS is to locate a person who is unaware of his exact location, for example in case of any injury and criminal attack. When the exact location of the person is known, the services can be provided quickly. Emergency calls from fixed telephone networks can be located accurately based on the callers address databases and emergency assistance can be rendered quickly [31]. In wireless network, location is available only if it is known to the caller and conveyed to the emergency dispatcher. The United States federal communication commission known as FCC, established a mandate for wireless Enhanced 911 (E911), that obligated mobile operators to route the emergency call to public safety answering point (PSAP) which is an office or call center where emergency calls arrive and determine the location of an emergency call. Location information is not only transmitted to the call center for the purpose of sending emergency services to the scene of the incident, it is used by the wireless network operator to determine to which PSAP to route the call [27].

3.1.2 Navigation

The main intention of the navigation is to guide the users (pedestrians or drivers) towards their destination. When the drivers requests for directions to certain location, the service gets the user location automatically and calculates the route to the user's destination. Optimized routing involves in avoidance of traffic congestion, early warnings of diversions, accidents and road works. Early systems didn't take into considerations the one-way systems, in order to take the user through the shortest route in terms of distance, ended in putting them through town centre at rush hour [8]. However, modern systems rectified all of the above complaints and often map data is updated and take into consideration the traffic concerns. Figure 3.2. shows the TomTom, which is helpful in guiding the users to reach their destinations.

Figure 3.2 *TomTom Navigation unit (Adapted from [31])*

3.1.3 Information on Demand

According to [28, 9], Location Based Services are used in information services like providing information in travel, tour guides for the users. User can request the service based on his\her location. Examples include finding the nearest service, to get traffic news, banks, finding the post office and so forth. When navigating in an unfamiliar city, services like guided tours can be provided to tourists in moving around.

3.1.4 Tracking Application

One example for tracking application is fleet management (for example tracking of trucks and taxis). The tracking services can be applicable to both consumers and co-operate markets. The delivery vans report at regular intervals throughout the day. The company knows the nearest van to send for a service requested by the user, calculate the travel time before distributing the tasks for the driver. This way the performance and utilization increases, which in turn reduces the operating costs. Other example of tracking is tracking of the postal package, so that companies know where their goods are at any time. Customer can view the location information and location data viewed by the customers helps them to know their expected delivery time.

3.1.5 Location based advertising

Location Based Advertising is about creating more personalized offerings based on user's profile and user's current location advertisements. When the subscriber indicates to the service that he is in shopping mode, he receives sales information, discounts based on his current location. The value added features like coupons can be pushed into the users mobile. Advertisers could be charged by the response rate [8].

3.1.6 Location Based Charging

Location Based Charging (LBC) is the ability of a mobile location service provider to dynamically charge the users for using a telecommunications services depending on their location. Location information is provided by the server of the network operator to provide subscribers with a customized charging scheme depending on the geo-graphical zone. LBC presents the opportunity to individually define and to benefit from geographical areas or zones that have been custom-designed for that particular subscriber's daily route and life-style. With location-based charging subscribers are provided with the ability to define their own zones comprising some favorite places for example, home, work or travel place. Furthermore, different rates may be applied in different zones based on the time of day or week and this model also notifies if the user is out of home zone and tariffs and pricing will also be specified respectively [2].

3.1.7 Geo- Mobility Server

According to [24], to realize a location based service a number of different players ranging from technology providers to data providers have to be involved. To ensure that all the different technologies and devices work together common standards for interfaces and description have to be defined. Such standards with respect to LBSs have been set up by the international standard organization (ISO) and by the open geospatial consortium (OGC). OGC released a specification for open location services (OpenLS). OpenLS defines core services, their access and abstract data types which form together a framework for an open service platform, the so called geo-mobility server. The server acts as application server and should proceed and answer core service requests. The core service components include directory service (spatial yellow pages), gateway service, location utility service (geo-code/ reverse geo-code), presentation service and route service.

Directory service gives access to an online directory to find the nearest or specific place, product or service. Examples of this service include finding the answers to the questions “Where is the nearest Indian restaurant to my hotel?” and “Which Indian restaurants are within 500m of my hotel?”. Gateway service is the interface between the geo-mobility server and positioning service and it is useful to request for the current location. Location utility service provides geo-coding and reverse geo-coding services. Geo-coding is the process of assigning x and y co-ordinates (latitude, longitude) to an address to be displayed on a map. Address interpolation is known as geo-coding technique. With the geographic co-ordinates the features can be mapped and entered into Geographic information systems or the co-ordinates can be embedded into media like digital photographs via geo-tagging. Reverse geo-coding is exactly the opposite of geo-coding. It will find the address, given the latitudes and longitudes. Reverse geo-coding is helpful in real time to find an address, example landmark of the Gas station given the current location [30]. There are several advantages to use geo-coding for maps. One real time example is rapid response to earthquakes, through Zip codes as everyone knows in which Zip code they are in. Also if you can add property information, it is more accessible to many users.

Presentation service renders geographic information for display on a mobile terminal. An application may call upon this service to obtain a map of a desired area, with or without map overlays that depict route geometry, point of interest, area of interest, location, position and/or address. Route service determines a route for a subscriber. The user must indicate the start point and the endpoint. The subscriber may optionally specify waypoints, the route preference for instance fastest, shortest, least traffic, most scenic and the preferred mode of transport.

3.1.8 Augmented Reality

According to [31], this is next decade plan. Researchers plan to pull graphics out of the phone or computer display and integrate them into real-world environments. This is called augmented reality. User can see real world around him with computer graphics super-imposed with the real world. Figure 3.3 gives an idea of how these applications are fitted into the architecture of LBS. LBS platform has applications geo-coding, reverse coding, routing and proximity search, which forms the basic components. The application developers build custom made applications on the application platform.

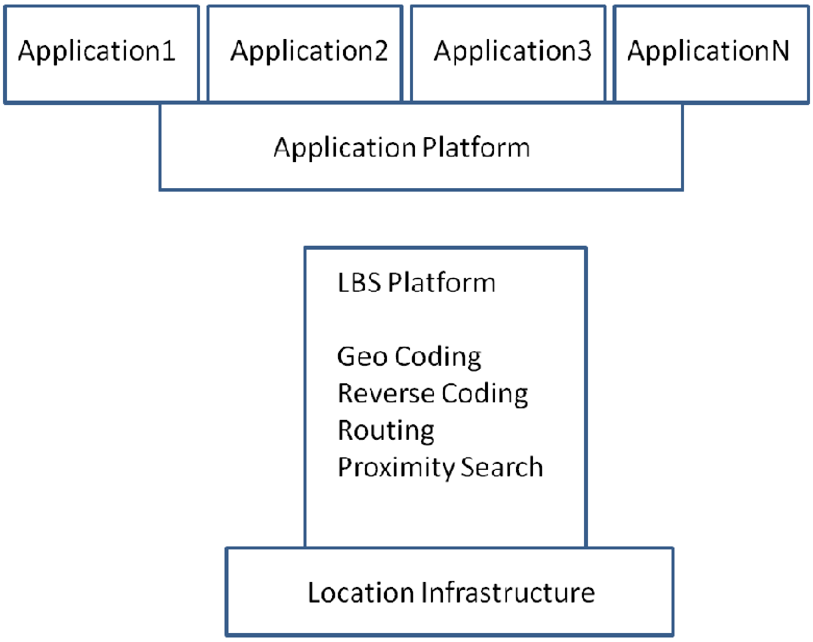

Figure 3.3. *Location Based Applications on the LBS platform (Adapted from [32])*

3.2 LBS Standards

In order to realize LBS, many actors are involved in it. They include for instance, service providers, hardware suppliers, software vendors, content providers and data providers To ensure different technologies and devices work together common standards have to be adopted. Many institutions, organizations and forums are working on standardization for LBS. Some of them are discussed in the following.

OMA (Open Mobile Alliance) [22]: This was formed in 2002. It develops open standards for mobile phone industry. Its main mission is to provide interoperable service enablers working across countries, operators and mobile terminals. OMA specifications are same with GSM, UMTS or CDMA networks.

IETF (Internet Engineering Task Force) [20]: The main aim of IETF is to make internet work better by producing high quality, relevant technical documents that influence the way people use and manage Internet. It drafted new protocol called SLOP (spatial location protocol). The purpose of this protocol is to have a standard way for an application or object associated to a physical entity.

OGC (Open GIS Consortium) [20]: This is an international voluntary standard organization. There are more than 400 commercial, governmental, non-profit and research organizations worldwide encouraging development and implementation of open standards for geo-spatial content and services. OGC is also devoted to develop interoperability standards using spatial or location information on the internet. OGC protocols support GML 2.0 (Geographical markup language) for storing and transporting the geographical information for applications.

3rd Generation Partnership Project (3GPP) [9]: 3GPP is a global standardization body, created in December 1998, is collaboration between groups of telecommunication associations known as Organizational partners. The main partners are the European Telecommunications Standards Institute, Association of Radio Industries and Businesses/Telecommunication Technology Committee (ARIB/TTC) (Japan), China Communications Standards Association, Alliance for Telecommunications Industry Solutions (North America) and Telecommunications Technology Association (South Korea). The main goal is to make globally applicable 3G mobile phone specification based on the GSM specifications and produce globally applicable technical specifications and technical reports for a 3rd generation mobile systems.

4. PRIVACY IN LOCATION BASED SERVICES

The increasing commercial potential and rapid growth of location based services (LBS) have been accompanied by concerns over the collection and use of personal information by unauthorized parties or by the service providers itself. Knowledge of location opens the possibility for providing highly personalized services and applications, at the same time the improper or unauthorized use of location can be a threat to individual privacy. Recent studies also indicate privacy concerns, where the employees are worried about their employers, who are keeping an eye on them to fears of tracking by potential stalkers are a serious obstacle to wider adoption of location-based services [18]. Location privacy is the right of individuals to decide how, when and for which purposes their location information can be released to other parties [19]. Location based spam messages considerably intrude on people's right to be let alone and it is feared that a spamming problem could emerge in the mobile world as can be observed today on the Internet. As a result of this potential threat, EU Commission has recognized the privacy importance in its directive called Privacy and Electronic Communications. The main points in the directive are listed below [29]:

- Automated calling is only allowed, when subscribers have given their prior consent.
- Only the body the user had made contract is allowed to use the contact details of the user
- Electronic messages that conceal the identity of the sender or without a valid reply address are prohibited.
- The location service must inform the user, prior to obtaining their consent, the type of location data that will be processed, the duration of processing and whether the data is transferred to third party.
- User shall be given the possibility to withdraw their consent for the processing of location data at any time.
- Users must have free of charge for temporarily refusing the processing of location data.
- Location data may only be processed when it is made anonymous or with the consent of the user for the duration necessary for the provision of a service.

4.1 Conceptual Model for Privacy

A theoretical model is developed by the [11] that links privacy assurance approaches to individual privacy decision making process. It further considers how culture may moderate the effects of privacy assurance approaches on influencing user's privacy risk and information control perceptions. The conceptual model depicted in Figure 4.1. considers the role of perceived privacy risk, privacy assurance approaches, perceived information control and culture with respect to the users.

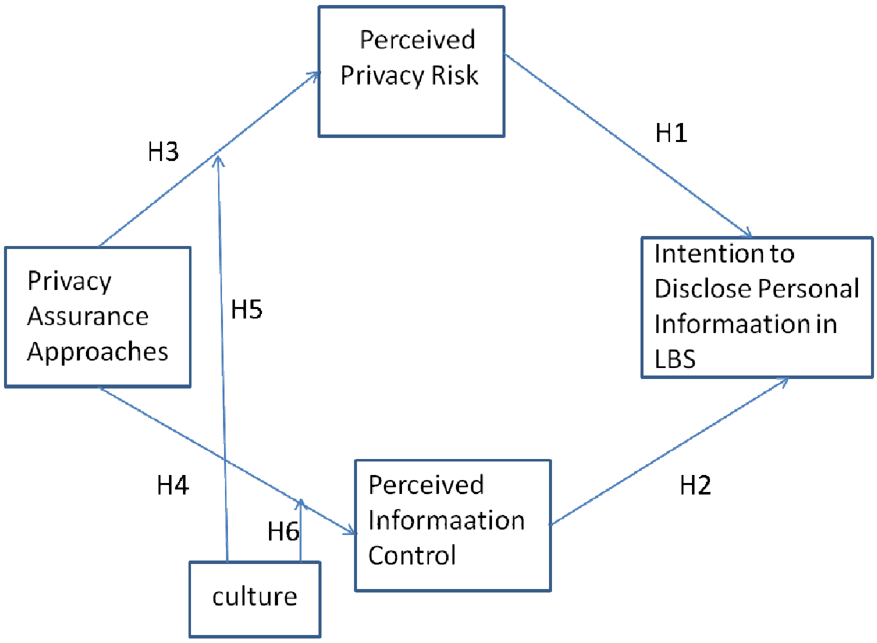

Figure 4.1. *Conceptual model for privacy (Adapted from [11])*

Perceived Risk: Perceived risks are considered as the expectation of losses associated with the release of personal information to LBS service provider. Perceived risks are considered as the major objection factor in adoption of LBS. When information is misused there will be negative consequences and the users are less likely to participate in the activities that need information disclosure. Hence the model makes an observation called H1, defined as follows and depicted in Figure 4.1.

H1: Perceived privacy risk negatively affects intention to disclose personal information in LBS.

Perceived Information Control: Consumers find it unacceptable to sell information for marketers about them and they object to the secondary use of personal information without their knowledge. So, perceived control over personal information is strongly related to individuals' intention to disclose personal information in LBS. Individuals tend to perceive disclosure as less privacy-invasive when they believe that they have control over the disclosure and use of their personal information. The higher levels of perceived control over personal information should lead to higher level of information disclosure. Hence the observation from this model is H2 as follows and is depicted in the above the Figure 4.1.

H2: Perceived information control positively affects intention to disclose personal information in LBS.

Privacy Assurance Approaches: This model considers three privacy assurance approaches for assuring information privacy which are privacy enhancing technologies, industry self-regulation, and government legislation respectively. Privacy enhancing technologies PETs, also known as privacy enhancing or privacy-enabling technologies, defined as a technology that is designed to guard the privacy interests of individuals. PETs could empower consumers with primary control over the disclosure and access of their personal information that is gathered by online companies. They comprise tools that allow consumers to protect their information privacy by directly controlling the flow of their personal information to others, such as LBS providers. Industry self-regulation mainly consists of industry codes of conduct and self-policing trade groups and associations as a means of regulating privacy practices. These are reinforced by the third party intervention, which involves setting of standards by an industry group or certifying agency. The members have to adhere to these standards. An example of industry self-regulatory groups is Trustee, BBB online and online privacy alliance. They have their privacy principles and guidelines to safeguard privacy of personal information. Finally, government legislation is the other commonly used approach for assuring information privacy, which relies on the judicial and the legislation approach that embodies the assurances provided by government agencies have a strong impact on protecting consumer privacy. Each of the three privacy assurance approaches can potentially reduce privacy risks and enhance perceived control.

H3: Different privacy assurance approaches (in terms of PETs, industry self regulation and government legislation) will affect perceived privacy risk differently.
H4: Different privacy assurance approaches (in terms of PETs, industry self-regulation and government legislation) will affect perceived information control differently.
Culture: This model considers cultural dimension called individualism and collectivism. In a collectivist society, individuals regard group interests as more important than individual interests. Thus, collectivists prefer a cohesive and tightly knit social society and rarely move in and out of groups. A society high on individualism instead implies a loosely knit society in which people consider themselves to be independent of others, pursue personal goals, can move in and out of groups easily. India is an example of a collectivist culture and the US is an example of an individualist culture. Collectivists tend to decide by standard operating procedure rather than weighing the pros and cons and they are less likely to perform a risk-control calculation for different privacy assurance approaches. Individualists consider privacy risks against control for different privacy assurance approaches. The observations made are H5 and H6 respectively which are depicted Figure 4.1.

H5: The influence of privacy assurance approaches on perceived privacy risk will be different for individualists and collectivists.

H6: The influence of privacy assurance approaches on perceived information control will be different for individualists and collectivists.

An experimental study was conducted to test the proposed model and found that all the observations they made in this model are supported. It is also observed from the experimental study that the privacy awareness is relatively low in India as compared to US, where many people have at least heard about victims of fraudulent practices. Another interesting observation made here is that Privacy law appears as a relatively stronger means of control as compared to other approaches for both cultures. PETs were considered to be a relatively weaker mechanism for enhancing control and reducing privacy risk in both India and US compared to self regulation and Government Legislation.

4.2 Concepts of Location Privacy

This section gives an overview of various location privacy concepts including location k-anonymity, location obfuscation and location spatial cloaking respectively.

Location *k*-anonymity: According to [17,18 and 19], Anonymity is derived from the Greek word “anonymia” meaning, without a name or nameless. Typically anonymity refers to personal identity of the individual being publicly unknown. This model was proposed by Sweeny, is widely used in maintaining privacy in databases. Each row is termed as tuple and tuples within a table are not necessarily unique and each column is called attribute, which gives information about set of possible values. The concept of *k*-anonymity addresses how a data holder can release private data with guarantee that the individual subjects of the data cannot be identified, whereas the data remain practically useful. For instance, a medical institution may want to release a table of medical records with the names of the individuals replaced with dummy identifiers. Figure 4.2. and Figure 4.3. show the medical data and voter’s registration list of persons, an attacker can easily discover Enna, Anna and Sidu individually suffered from which diseases by joining (Figure 4.2. and Figure 4.3.) on Sex, Birth date, Zip code, as shown in Figure 4.4. A set of attributes that can be potentially linked with external information to re-identify entities is a Quasi-Identifier. The identifiers Sex, Birth date, Zip code, are called Quasi-Identifier for this example. To counter linking attacks using quasi-identifiers, Samarati and Sweeney proposed a definition of privacy called *k*-anonymity. A table satisfies *k*-anonymity if every record in the table is indistinguishable from at least $k - 1$ other records with respect to every set of quasi-identifier attributes such a table is called a k-anonymous table. Hence, for every combination of values of the quasi-identifiers in the k-anonymous table, there are at least k records that share those values. This ensures that individuals cannot be uniquely identified by linking attacks. Figure 4.5. and Figure 4.6. explains the concept of *k*-anonymity, a collection of attributes zip code, age, nationality being the quasi-identifier. A 4-anonymous table is arranged in Figure 4.6., where “*”

denotes a suppressed value. For example, “zip code = 130*” means that the zip code is in the range [13053−13095] and “age=3*” means the age is in the range [30 − 39].

sex	Birthday	Zip-Code	Disease
male	23-09-56	33720	flu
female	30-04-87	33675	cancer
female	28-09-67	33100	infection
female	20-10-96	33101	cancer
male	12-09-78	34104	Eye - problem

***Figure 4.2**. Medical data (Adapted from [39])*

Name	Sex	Birthday	Zip-Code
Anna	female	30-04-87	33675
Enna	female	20-10-96	cancer
Biru	male	01-09-78	Eye-problem
sidu	male	23-09-56	flu

***Figure 4.3.** Voter registration list (Adapted from [39])*

Name	Disease
Anna	cancer
Enna	cancer
sidu	flu

***Figure 4.4**. Result of joining medical data and voters registration list (Adapted from [39])*

	Zip-Code	Age	Nationaly	Condition
1	13053	28	Russian	Cancer
2	15058	45	American	infection
3	13053	21	Indian	Lung Disease
4	15058	48	Indian	infection
5	15058	50	Japaneese	infection
6	13053	23	American	Lung Disease
7	13095	31	Russian	cancer
8	13095	36	Japaneese	cancer
9	13053	29	Indian	cancer
10	13095	37	Russian	infection
11	15058	54	Japaneese	cancer
12	13095	35	Russian	infection

***Figure 4.5.** Inpatient data (Adapted from [17])*

	Zip-Code	Age	Nationality	Condition
1	130**	<30	*	Cancer
2	130**	<30	*	Lung Disease
3	130**	<30	*	Lung Disease
4	130**	<30	*	Cancer
5	150**	>40	*	Infection
6	150**	>40	*	Infection
7	150**	>40	*	Infection
8	150**	>40	*	Cancer
9	130**	3*	*	Cancer
10	130**	3*	*	Cancer
11	130**	3*	*	Cancer
12	130**	3*	*	Infection

***Figure 4.6.** 4-anonymous Inpatient data (Adapted from [17])*

In the context of LBSs and mobile clients, location *k*-anonymity refers to the *k*-anonymity usage of location information. In the context of Location Based Services, for each location query information or message there should be (*k*-1) messages with same location information, with pseudo-identity.

k-anonymity has some short-comings, e.g.., it does not provide privacy if the attacker has background knowledge. The attacker can use sensitive attributes to know the information about the user. There are also chances for homogeneity attack on the information, because of the values within equivalence class lack diversity [38]. Figure 4.7. shows the homogeneity and background attacks.

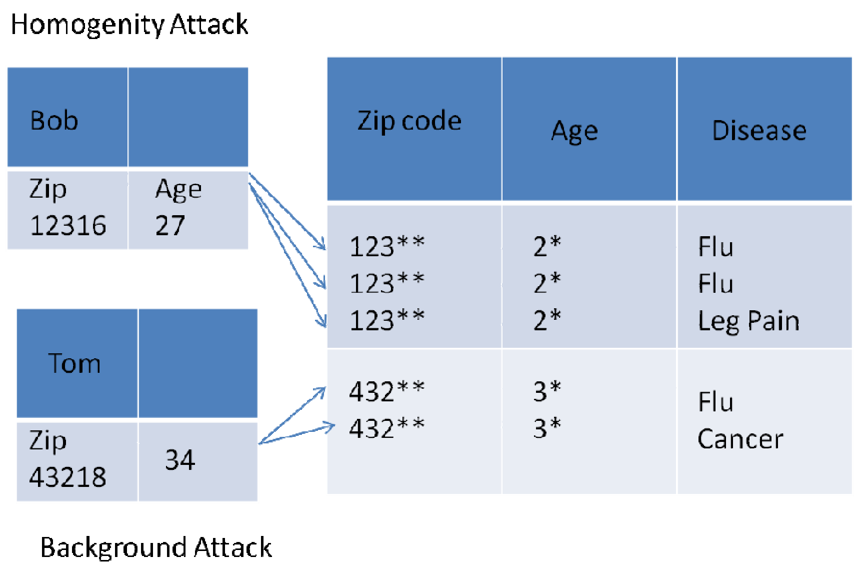

Figure 4.7. *K-anonymity model drawbacks (Adapted from [39])*

There are many methods which can overcome the shortcomings of the k-anonymity model. They are l-diversity model, t-closeness, and m-invariance all these methods are based on k-anonymity model.

Location Obfuscation: Obfuscation reduces the quality of the location data. Location privacy can be increased by intentionally obfuscating the location data, like adding noise or reporting regions instead of points. According to [3], location position of users is always represented as planar circular areas instead of geographical point. The more accurately the measurement is done results in reduced privacy. The location measurement depends on the radius of the measured circular area, returned by the sensing technology. Obfuscation can be created by enlarging the radius of the planar circular areas, shifting the centre of planar area and reducing the planar circular area. Figure 4.8., Figure 4.9. and Figure 4.10. details the obfuscation methods. Diagrams explaining obfuscation techniques can be found in Appendix 1.

Location Spatial Cloaking: This approach blurs the user's exact location into a cloaked area. The cloaked area contains at least k users and with minimum area Amin (the size of cloaked area is at least Amin). The location based database server doesn't know the user's exact location information; the database server can only return answers to the user.

4.3 Architectures for Hiding User Private Location Information

According to [18] and [19], the system architectures for preserving location privacy are non-co-operative architecture, third trusted party architecture and co-operative peer-to-peer architecture. The following sections describe how each architecture is useful in providing location privacy.

4.3.1 Non-Co-operative Architecture

In this architecture, the mobile users directly communicate with the LBS provider. The users try to cheat the server using false or fake identities or locations.

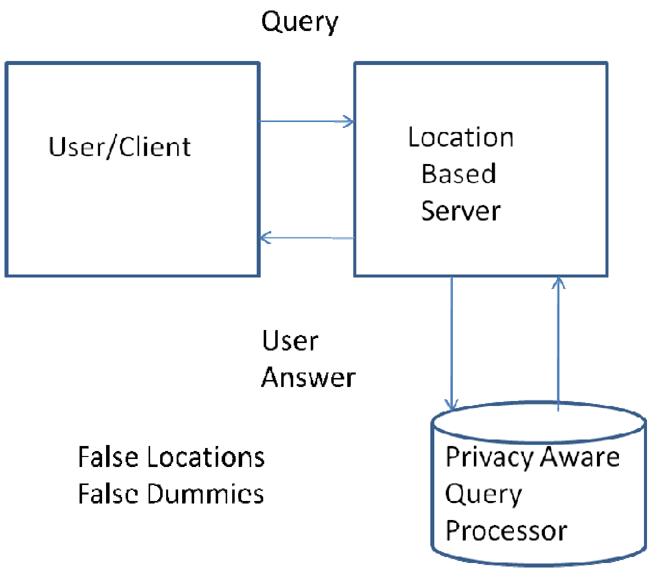

Figure 4.11. *Non-cooperative Architecture (adapted from [19])*

False Locations: The user sends the false locations, instead of his or her exact location. The user sends locations like closest landmark or significant object to the user's location. The answer will be based on the user's sent location. Figure 4.11. describes that the user sends query to the location based service server and for a location update, user sends m different locations to the server, where only one of them is correct, rest are dummies. The server doesn't know which of these the actual one is. The query processor finds the answers to each location and sends back to the user. The user later computes his location based on the answers sent.

4.3.2 Trusted Third Party Architecture

According to [25], to improve the privacy concerns of the users, the trusted LBS middleware is deployed. This is also called anonymizer. Anonymizer receives the location information from the mobile users along with privacy profiles from each user. The anonymizer will cloak the information and send this cloaked information to the server. The server is designed in a way, that it can deal the cloaked information. Usually privacy aware query processor is embedded in the server to deal with the cloaked information. Figure 4.12. describes that the user sends a query to the anonymizer, upon receiving the query the location anonymizer is responsible for blurring user locations into cloaked areas that satisfy user's personalized privacy requirements. The user privacy requirements are mostly presented in terms of the *k*-anonymity model, in which a cloaked area contains at least *k* users making each user indistinguishable among at least *k*-1 users. The query processor embedded inside the database server does not know the actual location information of the query or data, it can return only an answer set that includes the exact answer to the user regardless of the actual user's location within the cloaked area and finally the result is forwarded to the user. Examples of models which use this architecture are Casper, clique cloak algorithm and spatio-temporal cloaking. Today, for preserving the privacy, location anonymizer is widely used [19].

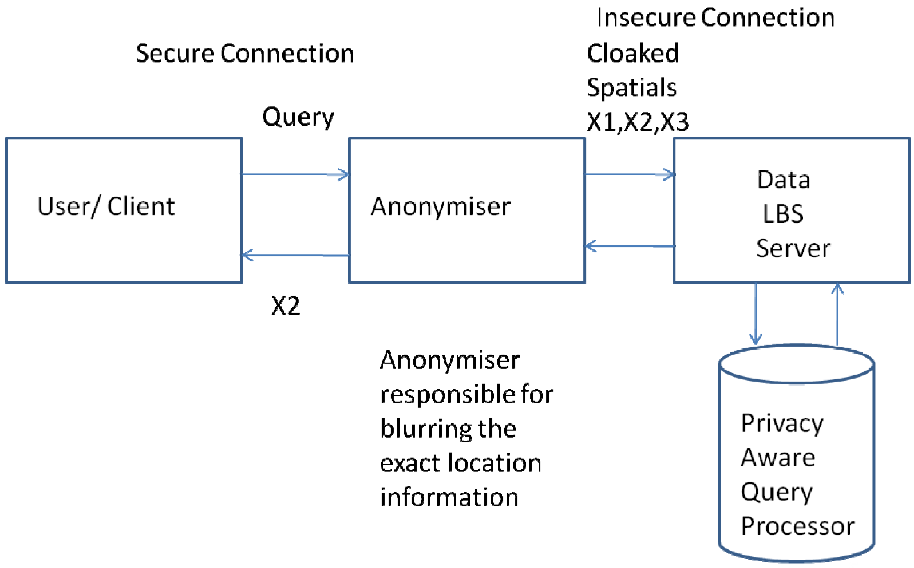

Figure 4.12. *Trusted third party architecture (Adapted from [25])*

4.3.3 Mobile Peer to Peer Communication Architecture:

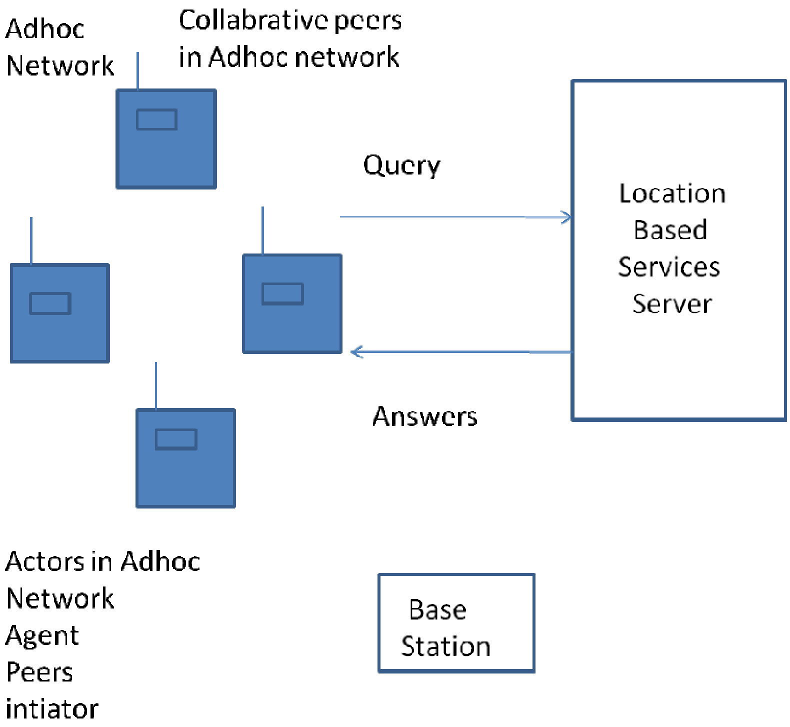

Figure 4.13. *Peer-to-peer Architecture (Adapted from [12])*

According to [12], the main actors of this architecture are collaborative peers, adhoc network and LBS server. Mobile users communicate with each other through a fixed communication infrastructure for example, base stations. In this architecture a group of mobile users collaborate with each other to provide location privacy protection for each single user. A peer is able to build ad-hoc network with others. The mobile user searches for *k*-1 peers and collaborates with them to form a cloak area. This adhoc network is created on fly, when peers have to exchange information with others to perform the respective tasks. The cloaked area satisfies the user's *k*-anonymity and minimum area Amin privacy requirements. Then, the user sends his/her location-based query along with the cloaked area to the LBS provider to obtain her desired services. Since the location-based database server does not know the exact user location, it can only return an answer set that includes the exact answer to the user. Thus, after the user gets the answer set from the database server, he/she has to compute the exact answer from the answer set.

5. BUSINESS MODELS TO EVALUATE LBS

Services and services innovation are directly related to and dependent on innovations in business models. Services require viable business models in order to be adopted by the users and long term profitability for the providers. This chapter introduces a conceptual business model called STOF (Service, Technology, Organization and Finance) developed by Bouwman [4]. This model is used in next chapter (Chapter 6) to evaluate and analyze LBS services for mountaineering from a business perspective. The core of this model is built around four inter-related domains: Service, Technology, Organization and Finance which make up the term STOF. This model is helpful in evaluating and introducing new services into the market successfully. This framework was mainly developed for mobile services and helps in identifying critical design issues (CDI's) of the business. CDI's are design variables that are considered as an important factor to see the viability and feasibility of the business model.

5.1 Service Domain

Service domain is the description of the value offering and the market segment at which the offering is aimed. Service system is aimed at providing added value for its users, where a service provider intends to deliver and delivers a certain value proposition and end-users expect and perceive a certain value proposition. The four parameters or concepts in the service domain are intended value, delivered value, expected and perceived value. Intended value is the service provider offerings to the customer and this value is considered as a starting point for a design. Intended value is translated into functional requirements, which in turn are transferred to technological design and technical specifications. Intended value is translated into requirements for value network in organizational design. The value a provider actually delivers to customers or end-users of the service is called Delivered Value. Expected Value is the value which the customers or end-users expect from the service, is usually based on their experience with previous versions of a service or similar services. Perceived Value is the customer or end-user actually perceives when they consume or use the service. Perceived value is considered as the difference between delivered value and the expected value. So, higher the delivered value or lower the expected value then the perceived value increases.

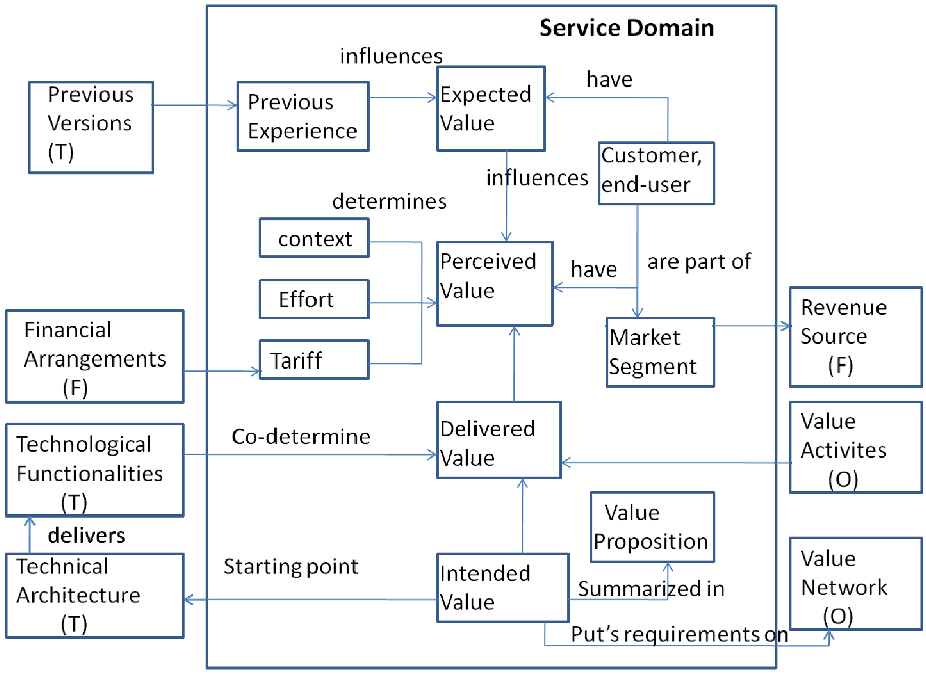

Figure 5.1. *Service Domain (Adapted from [4])*

Perceived value is co-determined by other factors as context, effort and tariff. A service is successful if it offers services in a specific context. Context is any information that can be used to characterize the situation of an entity and an entity is a person, place or object that is considered relevant to the interaction between a user and an application. Customer is the person who actually pays for the service and end-user pays tariff to consume services, also the end-user makes an effort to use the service. End users with different expected and perceived values are part of the market segment which refers to the size of target group, size of potential market, similar services which already exist in the market. The above concepts of the service domain are depicted in Figure 5.2. and the four values the intended value, delivered value, expected value and perceived value and their inter-relationships with the other domains are also depicted.

5.2 Technical Domain

Service design acts as first step in designing the services, they serve as a guide to technical design. As described in Figure 5.3., “Intended Value" in the service domain sets requirements on the technical architecture. The technical functionalities developed under this domain act as a parameter in determining delivered value as described in Figure 5.3. In order to make the service design realizable technical architecture is needed, which describes the overall architecture of the system and consists of service platforms, devices applications, access networks and backbone infrastructure. Service platforms refer to the middleware platforms, enabling the different functions like privacy, security, data management. End-Users use the devices for accessing the services. User applications run on the technological system and data streams are transferred through networks. Backbone infrastructure refers to medium and long range network infrastructure.

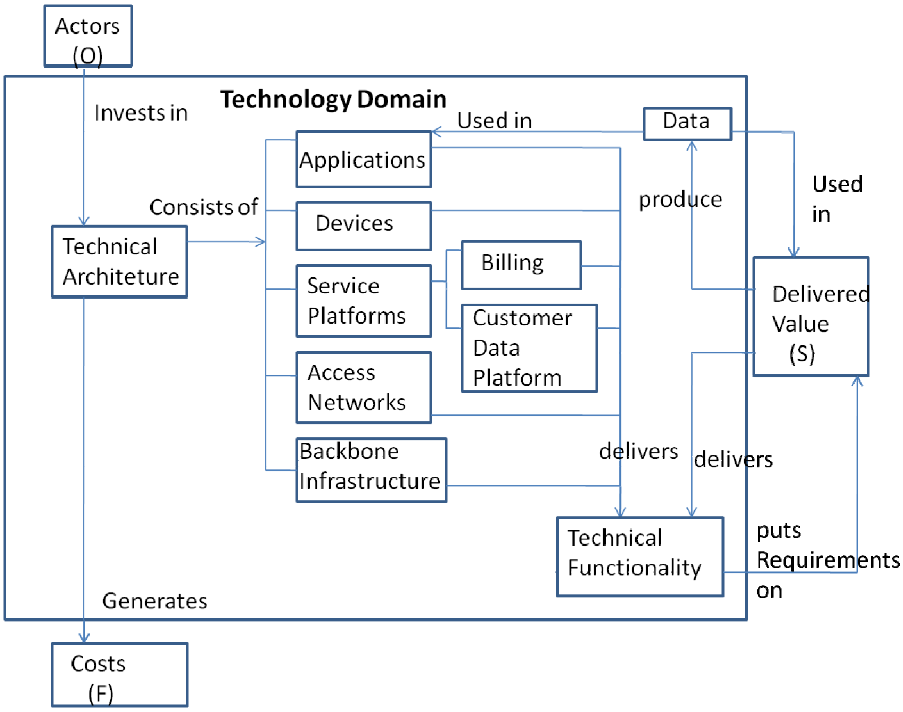

Figure 5.2. *Technology Domain (Adapted from [4])*

Service Acceptance: Figure 5.4. shows the variables needed for the system to be accepted. Quality of a service is determined by reliability (accuracy of product information, correct functioning of the services), responsiveness (providing appropriate service), user interface design (finding needed functionality without difficulty, overall ease of use), trust (having confidence regarding security and privacy when using the e-services). Figure 5.5. shows the various parameters responsible for making high quality service.

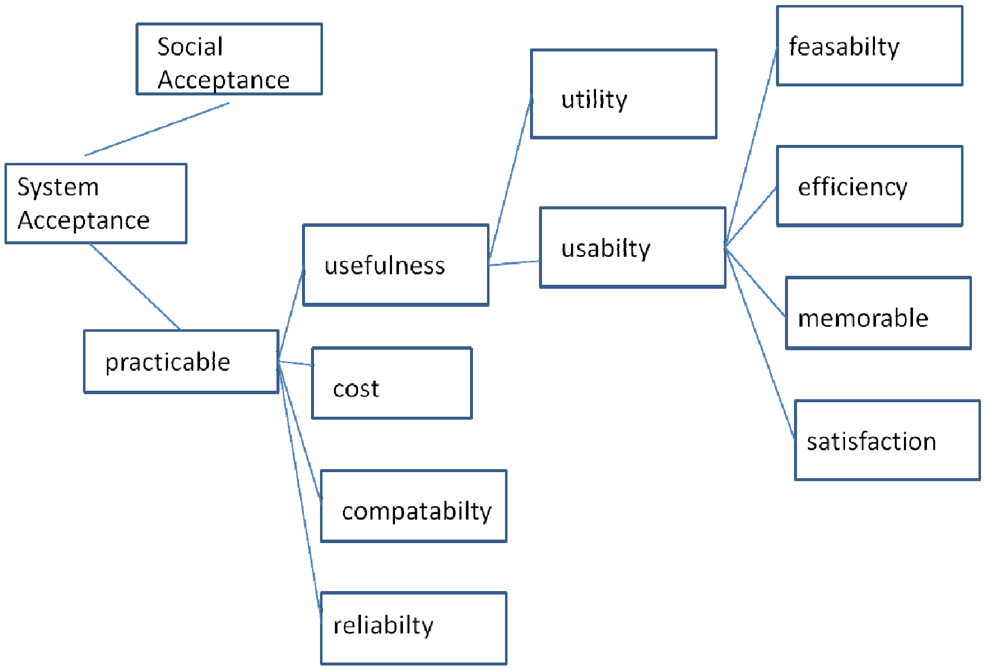

Figure 5.3. *Parameters for service acceptance (Adapted from [32])*

5.3 Organization Domain

Organizational issues revolve around the resources and capabilities, mainly related to technology and finance that have to be made available to enable the service. To implement a profitable, fair, transparent, and sustainable service, there should be a viable organization structure. Cooperation and coordination among different stakeholders are critical to the success of the system. The organization design describes the value network that is needed to realize the particular service offering. A value network consists of actors with certain resources and capabilities, which interact and together perform value activities, to create value for customers and to realize their own strategies and goals as described in Figure 5.4. Value Activities are the activities that an actor is supposed to perform in order for the value network to deliver the proposed service. Actors can have single or multiple roles like investors roles, governance body or technology provider. Resources and Capabilities can be financial, social, organizational and technical in nature. Value Activities of actors put requirements on Technical Architecture (technology domain), and generate Investments (finance domain), Costs (finance domain) and Delivered Values (service domain) as shown in Figure 5.5. The number of actors and the frequency and type of interactions contributes to the complexity and density of the value network. Relationships are important to a value network, because they contribute to trust and commitment within the network. All the actors must collaborate to meet the common goals and strategies. Collaborations lead to complex dependencies, every adjustment has to be discussed and jointly agreed as part of organizational arrangements. Figure 5.6. shows all the important concepts and variables in order to realize this domain.

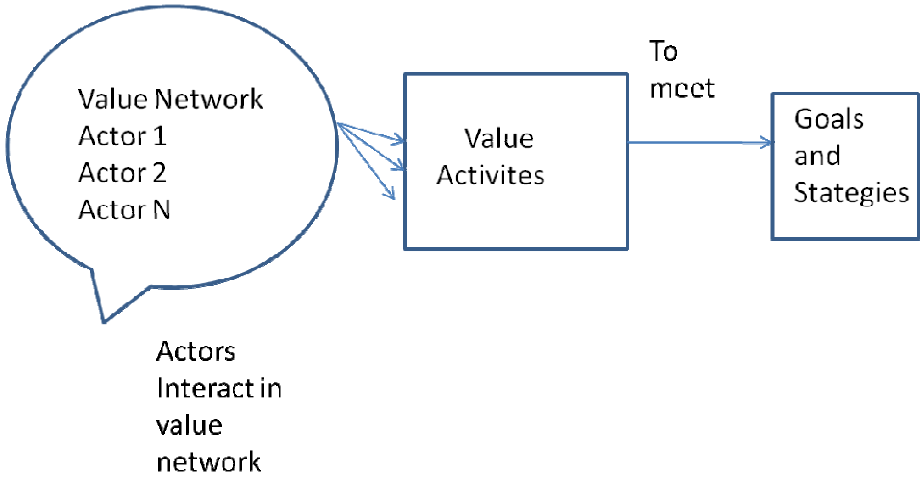

Figure 5.4. *Value Network in Organization Domain (Adapted from [4])*

5.4 Finance Domain

This domain describes the financial arrangements in the value network and shows how the actors intend to capture monetary value from the service. A financially beneficial situation is created for all actors in value network. The sharing and distribution of the

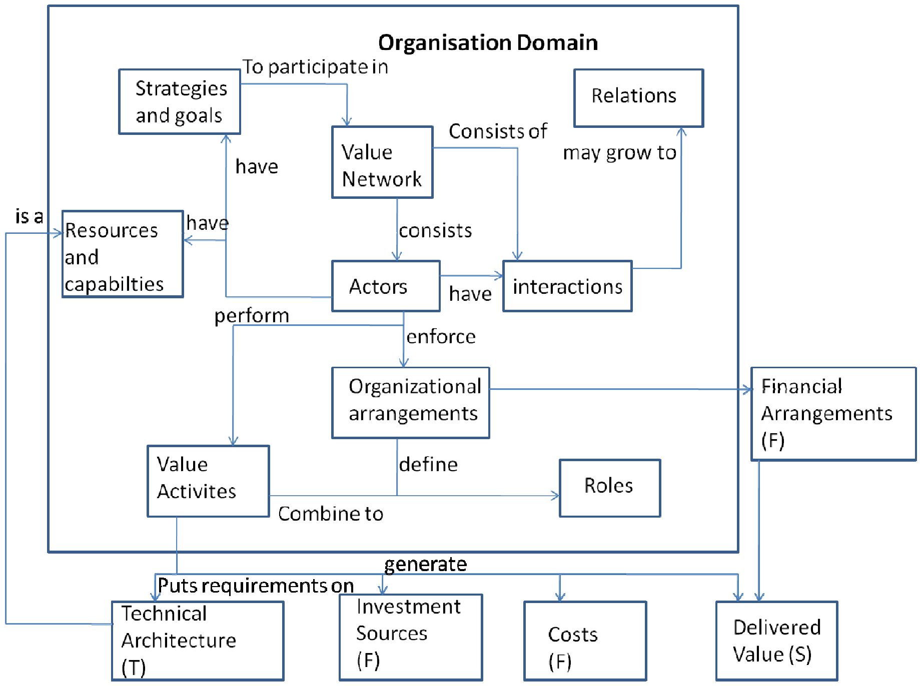

Figure 5.5. *Organization Domain (Adapted from [4])*

monetary value and costs should be balanced in a value network to benefit all the partners.

Investment sources, will supply the capital and this design variable is considered as important in the finance domain. Cost sources are also crucial design parameter, example of cost sources are, value activities of actors within value network and technical architecture choices in the technology domain, both are the cost sources, which generate costs. Revenue sources, where we get revenues from the services, like subscription charges, advertisements and government subsidy are some of the examples. Any design has the risks, which has a negative consequence, which might happen in the future. Risks in other domains have financial consequences, for example, if the perceived customer value is much lower than the assumed value this may have a negative impact on the revenues. The value network should cope up with such risks and make necessary financial arrangements. The financial arrangements between the actors in the value network describe the way profits, investments, costs, risks and revenues are shared among the actors and these agreements should clearly define the benefits for all actors involved. With regard to the evaluation and management of the financial arrangements over time, performance indicators for example market adoption, usage and return on investment are necessary. When the end-user is concerned pricing of the service is important. Pricing is determined by the financial agreements and the possible pricing structure can be on pre-pay or subscription based pricing, flat free charge, or per usage pricing. The parameters for the finance domain are described in Figure 5.7.

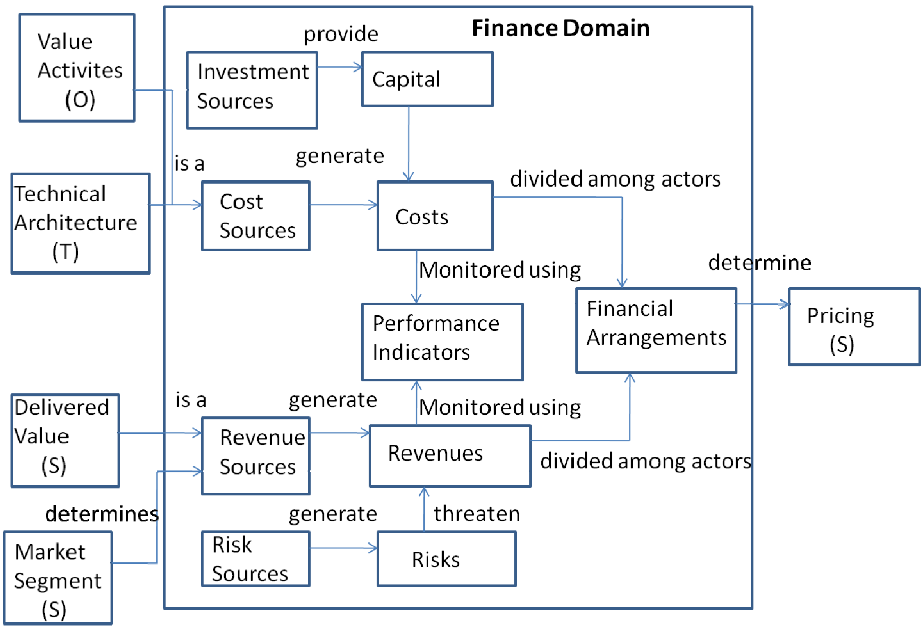

Figure 5.6. *Finance domain (Adapted from [4])*

The four domains are closely linked to each other, for instance, the Service domain puts requirements on the technologies used in the Technology domain as well as the value network in the Organization domain, while influencing the revenue sources of the Finance domain. Similarly, the technology domain influences the delivered value in the service domain, and the costs in the Finance domain. Likewise, the activities of the players in the Organization domain have a direct influence on the other domains, while the Finance domain, among other things, determines the pricing in the Service domain.

5.5 Critical Design Issues

According to [4], in addition to a descriptive model, STOF also identifies critical design issues that play a role in a viable business model. Bouwman identified CDIs in all the four domains are described below:

Service Domain: CDIs that originate from the service domain based are targeting, creating value elements, branding and customer retention.

Choosing proper target group and creating value proposition to the end-users is important for a successful business model. It should look into some examples, whether the business targeted is for the mass market or specific customers, youngsters or elders and hence forth. The value proposition of a service is a collection of the service's value elements for example; fun, speed and trust. Branding is considered as an important variable to reach the customers of target group. It is an important means to create the customer value. Another important variable customer retention is aimed to keep customers satisfied with product or service and service providers adopt different strategies for repeated usage of their services.

Technology Domain: CDIs that originate from the technology domain based are security, quality of service, system integration, accessibility for customers.

Trust of end-users and customers in a service offering is determined by the way security is implemented in the technical architecture. That is, the way in which access to a service is granted and how security of communication and stored information is realized. Security often requires a trade-off between ease of use or privacy considerations and preventing abuse. The performance of the technical architecture in delivering the technical functionalities has a profound impact on the service offering and perceived value. A balance between the quality of the service and the incurred costs has to be maintained.. The adoption of the service is determined by the extent to which the new service can be integrated into the existing technical infrastructure and the trade-off with system integration is between flexibility and costs. The accessibility of the service to the target group is influenced by the choice of platforms, devices and architecture.

Organization Domain: CDIs that originate from the organization domain based are partner selection, network openness and network complexity.

Partner Selection is an important design issue in acquiring access to resources and capabilities needed to realize a service offering. Firms need to decide whether to outsource certain activities or to perform. Partners are very important for the support of the business, successful selection of these partners helps in more viability of the business. The level of openness indicates the degree to which new business actors can join the value network and are allowed to provide services to customers. The value network consists of many actors and these actors will communicate among themselves to provide value added services. As there are many actors in value network, one need to manage them efficiently for value added services and network complexity mainly deals how to manage with increasing number of relations with the actors in value network.

Finance Domain: CDIs that originate from the finance domain based are pricing and division of investments.

With regard to the adoption and actual use of a service, the perceived customer value must at least equal, and preferably exceed, the price of a service pricing should be done carefully and different pricing strategies have to be followed for customer retention. There are financial risks involved in developing and introducing a new service, as there is uncertainty about the resulting return on the investment and division of investments have to be carefully divided among the members of the value network.

6. LBS IN MOUNTAINEERING

This chapter highlights the potential use of LBS in mountaineering. A study and demo project on use of LBS in mountaineering called PARAMOUNT (Public Safety & Commercial Info-Mobility Applications & Services in the Mountains) sponsored by European Commission is taken as reference. In Europe mountaineering is more popular in Alps and the following table gives the various mountains and mountaineering sports throughout the world. The following table 6.1 gives only few of the destinations.

Table 6.1. *Mountaineering destinations (Adapted from [21])*

EUROPE	Alps Caucasus Pyrenees Rile Mountain Tartan Mountains
NORTH AMERICA	Sierra Nevada of California Cascades of pacific Northwest High peaks of Alaska
ASIA	Himalaya Karakorum Pamir’s Tine Shan Andes
NEW ZEALAND	Southern Alps Japanese Alps South Korean Mountains
BRITAIN	Coast Mountains of British Colombia
Scandinavia	Mountains of Scandinavia (Norway)

Annually more than 150 million people of EU are searching for recreation in the mountain regions of Alps. At the same time there are also more people who are perishing in the mountains without proper guidance.

PARAMOUNT

PARAMOUNT is an acronym for “Public Safety & Commercial Info-Mobility Applications & Services in the Mountains”. The PARAMOUNT study is made in the Pyrenees and Alps, with the aim to improve safety and info-mobility capabilities for the people who do outdoor sports and make recreation fun. The service’s main objective is to develop a user friendly info-mobility service for mountain hikers by combining the technologies of Wireless Communication, Satellite Navigation (GPS) and Geo-information or geographical information. The project started on 1 February 2002 with the duration of the project as 18 months. After successful completion of the project, the idea was to make the service available commercially, which is very helpful to the hikers and nature enthusiasts. The following sections study the use of LBS in mountaineering simultaneously mapping respective service in PARAMOUNT. Business perspective is analyzed using STOF model in all of its four domains.

6.1 Service Domain

This service is integrated on smart phone, (smart phone is a high-end mobile phone built on a mobile computing platform, with more advanced computing ability and connectivity). The electronic tour guide connected to the PARAMOUNT service through the internet will wirelessly assists the mountaineer in the position, orientation and navigation task, delivers environmental and additional information and helps in an emergency situation or even prevents it. This service not only benefits the users, but also safety and rescue team (SAR team) members, who can locate the point of accident using this service and can deliver timely help for the needed. The core services of the service are Info tour, Safe tour and Data tour which are explained below.

Info Tour: This tour helps in guiding and providing routing assistance to users. Depending on the user's current location, helps them to download and visualize the maps, provides point of interests (POI's) for instance, mountain summits, public transportation stations, huts and hotels, after selecting a destination the service determines the best route. If the user gets lost, for example due to poor weather visibility the user can request the route back to a trail. If the weather becomes too bad for walking or if the user is exhausted and needs to rest, the system even finds the route to the nearest hut. Besides the user will have access to local weather forecasts as well as common tourist information depending on his/her position. To clearly view or for the better orientation to surroundings, user can request from the server 3D picture of the surrounding hills with an emphasized trail on it. The system provides walking, hiking or skiing routes to the user and the user decides what he wants, the mobile client sends request and receives the available trails in the area of interest.

Safe Tour: In addition to the information described in the Info tour, this component comprises especially safety relevant data. The mountaineer can send an emergency call including his/her current position in case of emergency. If the user witnesses any accidents he can call the authorities and provide information about the distressed person to the SAR teams and can also define the witness of the victim on the map. This service component also tracks the users in the critical environments and in dangerous terrains. The SAR team members from the SAR Centre can track the movements of their rescue teams on the map and provide the needed information. To allow for an efficient and appropriate help for the tourist in case of an emergency, it is useful for the rescue people to have some relevant information on the general state of health (for example an existing cardiac insufficiency or the need for special medicine). Willing users can store this information on the server. The user also gets information about thunderstorms and bad weather. The user receives the information through acoustic signals and message boxes on the screen for their safe trip. The SAR client, used for safety and rescue operations is shown in the following Figure 6.1.

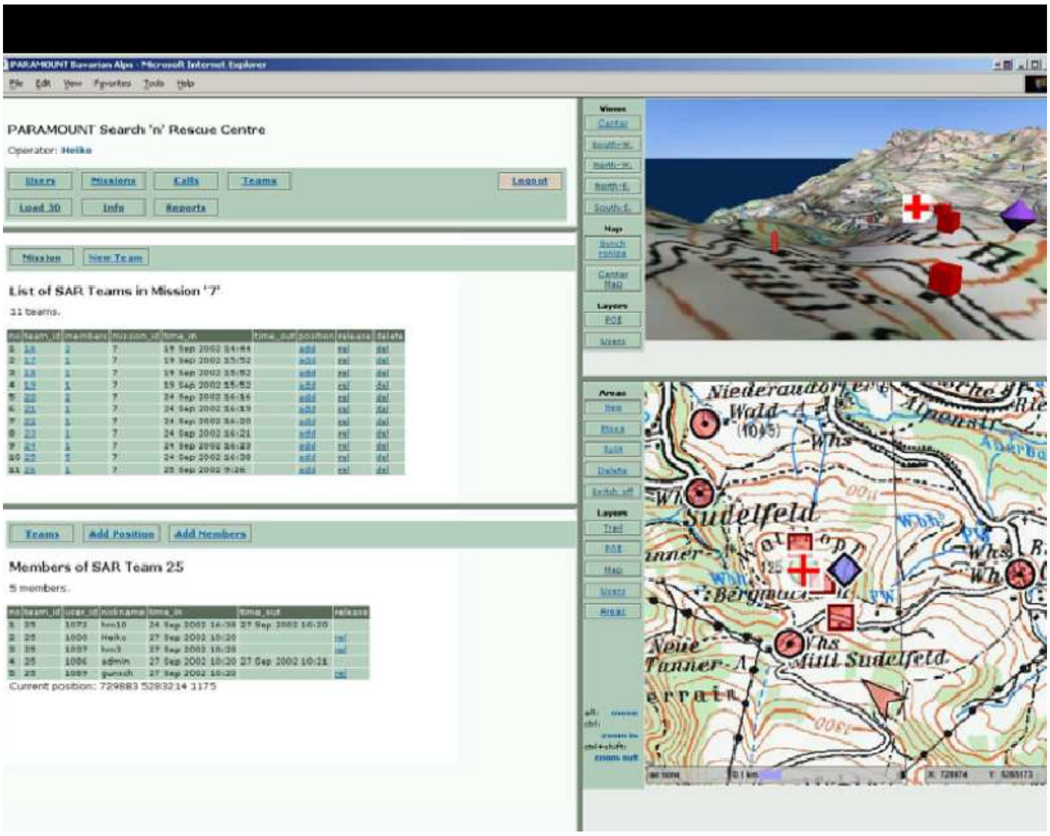

Figure 6.1. *SAR client (Adapted from [26])*

Data Tour: The PARAMOUNT users are directly involved in the data acquisition and maintaining process. This is a security sensitive matter and this service is only available to a group of registered users. This service allows mobile device to log the hiked routes for further evaluation by the user. The user can download these log files at home, display the hiked routes within a mapping program, they can calculate average hiking speeds for up and downhill, share the information with friends and can add some notes to the point of interests (POI's), make Personal evaluation about the severity of the trails to have more specific routing. This service also makes it possible to log the used trail to update the trail network and derive new trails. The user can update his information later in the databases and if more users are contributing to this service, the database is updated and is cheap way for the service provider to have updated information. Figure 6.2. depicts the service offerings of PARAMOUNT.

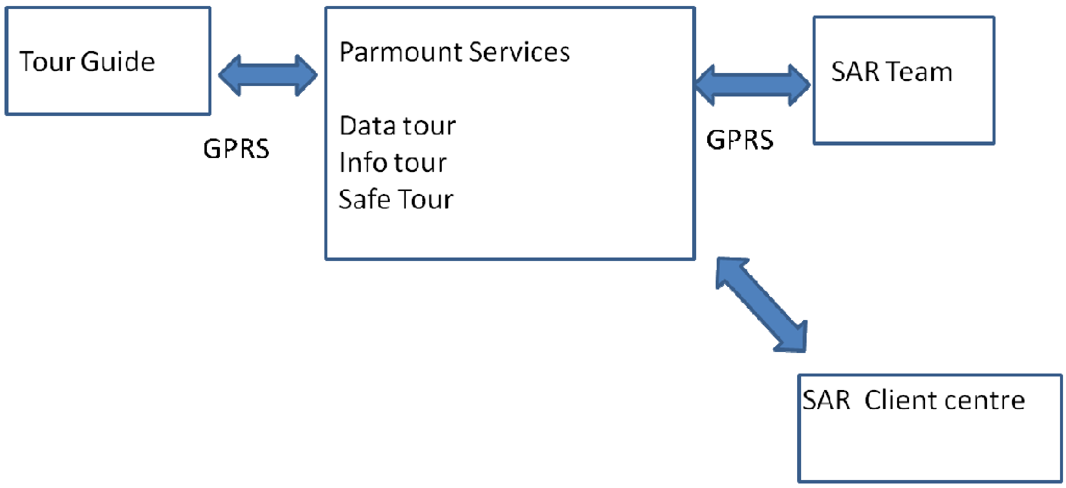

Figure 6.2. *Paramount services Overview (Adapted from [26])*

The services are used by hikers, sports enthusiasts, nature explorers and people who want recreation activities. Mountain rescue teams also use these services. If the services are used by the user context they want different information and the PARAMOUNT system from the hiker context is depicted in Figure 6.3. and if the SAR team member uses the service, they use in the context of providing safety to the users and the PARAMOUNT system from the SAR team member context is shown in the Figure 6.4. The SAR client functions are shown in the Figure. 6.5.

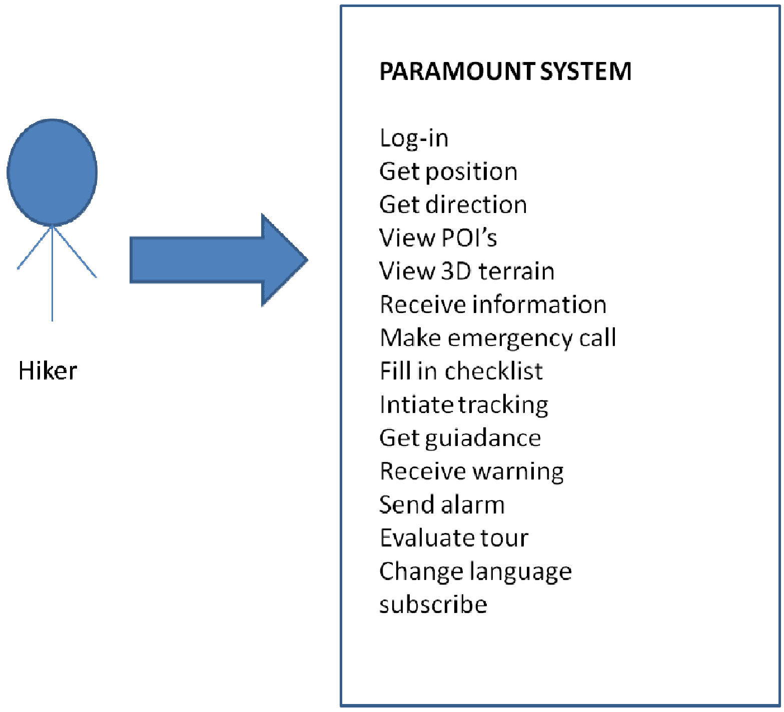

Figure 6.3. *Use case diagram of paramount system from hiker's context (Adapted from [26])*

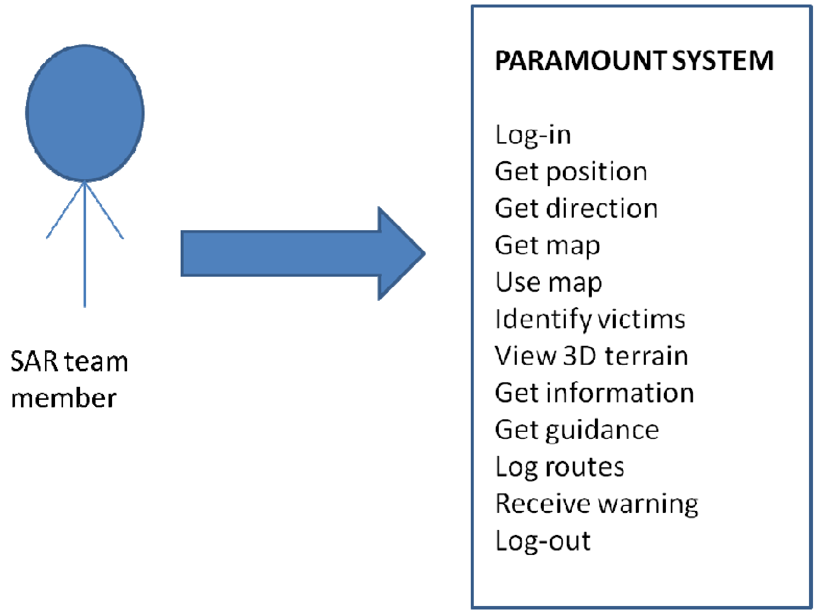

Figure 6.4. *Paramount services from SAR-team member context (Adapted from [26])*

The main objective of the PARAMOUNT service is to provide appropriate information and features for mountain hikers and wanderers with integration of support and control facilities for mountain rescue services to make the outdoor recreation as fun. Figure 6.6 depicts the value proposition of the PARAMOUNT service.

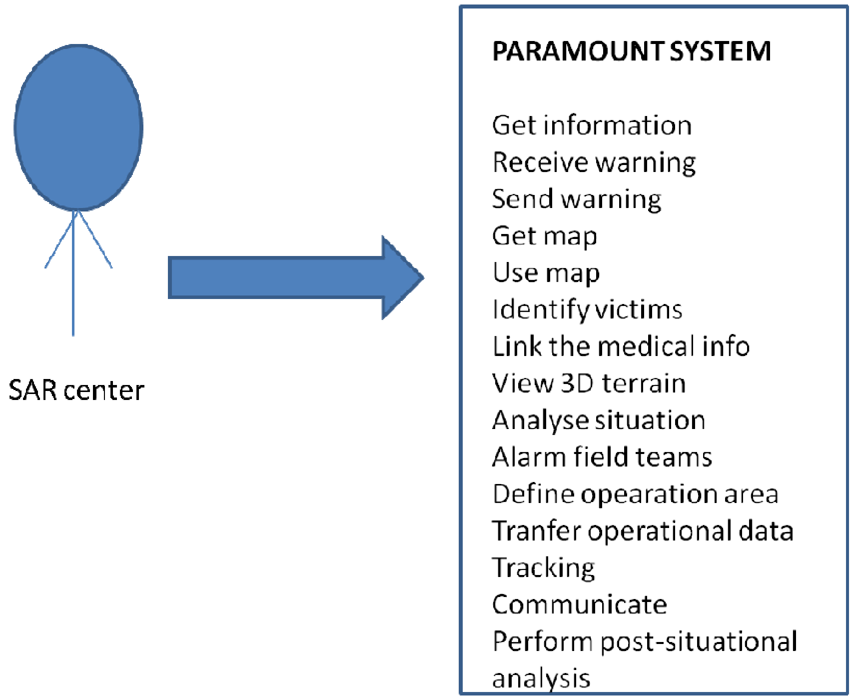

Figure 6.5*. PARAMOUNT services from SAR centre context (Adapted from [26])*

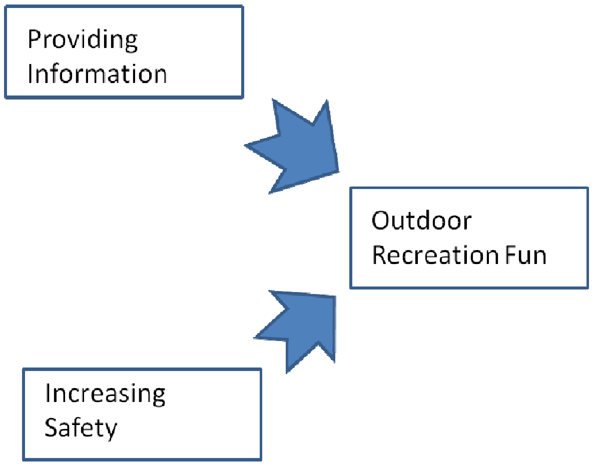

Figure 6.6. *Value Proposition for PARAMOUNT service (Adapted from [26])*

Research says that annually more than 150 million people choose this mountaineering only in EU, which makes the market segment to be big. In an unknown environment the users feel very lonely and lost and by using this service they are very confident about their whereabouts in an unknown area.

Branding helps the service to reach globally, concentrates on user's loyalty and motivates the potential buyer and makes the service recognizable on a large scale. There is a notion that if the goods are not branded then they are sold for lesser prices. If the application is branded with big players in mobile industry like Samsung, Nokia, and LG, this service will reach many users.

Customers are the key people for the business to be successful. Companies have to find ways to keep the customer retention. These services contribute for customer retention and another factor for customer retention includes building communities which encourages the customers to use PARAMOUNT service. The users should be able to establish communities. A hiker group or mountain bike group agrees to display their position on each other's mobile devices. Therefore all of them have to activate the tracking mode and allow each other to view their position. This is useful if for example average hiking speed is not equal to the whole group.

6.2 Technology Domain

The PARAMOUNT system can be described as three layer architecture which has tour guide client, PARAMOUNT server and data ware house as shown in the Figure 6.7. The tour guide communicates with the paramount server in order to have services processed. Mobile Internet which is a Global system for mobile communication\ general packet radio service (GSM\GPRS) technology is used for communication. Internet service portal (ISP) is an initial entry point to PARAMOUNT services. A first request to access PARAMOUNT services and information is handled by the ISP. The ISP need information such as mobile client's geographical location and command from the user, they together constitute the client's request. The ISP responses by supplying the necessary parameters for instance URL address, which directs the client to required service which includes info tour, safe tour or data tour. If there are any problems with the request, the ISP informs the client to re-initialize the request again and if the request is successful, the client can have direct connections to the respective PARAMOUNT services. Different types of data are needed to support paramount services and the types of data needed are vector, raster, attribute and multimedia data.

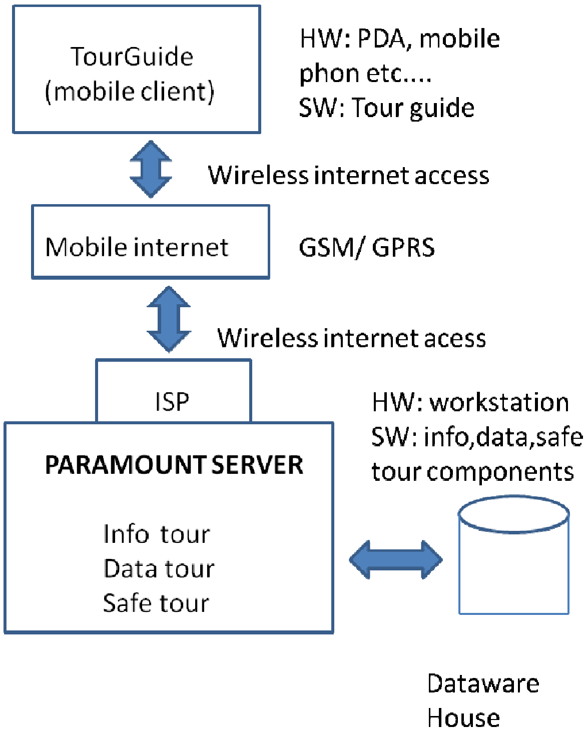

Figure 6.7. *PARAMOUNT system architecture overview (Adapted from [26])*

Two of the tested hardware arrangements for realizing this service are shown in Figure 6.8. The first one is the standard hardware for leisure hikers. It consists of a smart phone with integrated communication module. The second one is designed for professional use of the search and rescue teams. The tour guide application software has been developed for the Windows CE based Pocket PC operating system of Microsoft. All components have been implemented in C++ using the development environment Microsoft embedded Visual C++ 3.0. The Graphical User Interface (GUI) of the application has been designed for three different user languages: English (original version), German and Spanish. The mobile tour guide features are depicted in the Figure 6.9.

Figure 6.8*. Devices for PARAMOUNT service (Adapted from [26])*

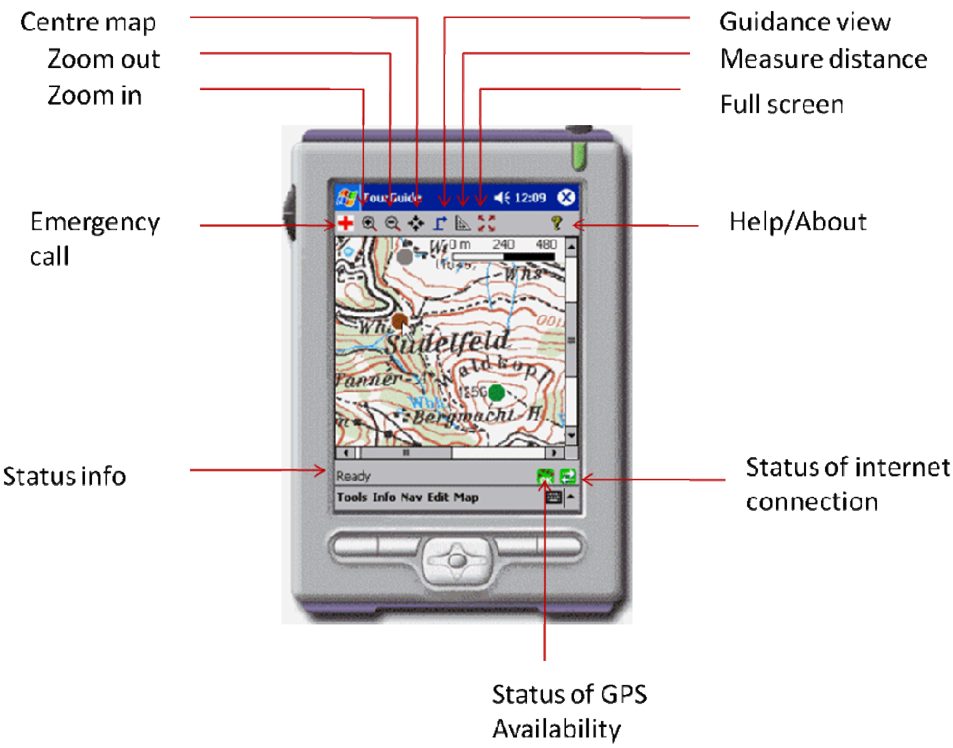

Figure 6.9. *Tour guide features (Adapted from [26])*

The user has to subscribe to the paramount services, in order to use the services. The users should identify themselves, after verifying identification the user will be logged in for security reasons. The personal information of the user should be stored safely and unauthorized usage of this information should be protected. According to a survey conducted about the service, the willingness to log user's routes and provide them to other users was low, only few participants agreed their willingness. Users have the capability to add or delete persons from the group for live sharing of his position with them, if he is not comfortable.

Quality of a service is determined by the parameters accuracy, reliability, responsiveness and user interface design [34]. PARAMOUNT services require the availability of GPS, GSM\GPRS and GIS. A study is made for each of the three components and found that the availability of GPRS, GPS and GIS has quite promising coverage for many areas of the Alps and Pyrenees, especially in the areas of high touristic relevance. The accuracy of the tour guide is found to be good, however problems are encountered in very severe environment for instance steep canyons or ravines. The user interface of the tour guide is user friendly. Not only internal tests were carried out but also with interested hikers as well as with SAR representatives. The external testers embraced the tour guide hardware and software and liked the functionality and the compact size of the equipment making. During the test phase it was experienced that the battery capacity is in fact well sufficient for day trips, however for multiple day trips it is necessary to recharge the batteries for each further day making the tour guide service reliable. The response of the service should be fast, the SAR members attested that the SAFETOUR features implemented in PARAMOUNT are very well suited to make SAR missions faster and more effective. Especially the transfer of exact position coordinates of the distressed person within the emergency call message is of paramount importance for the rescue teams.

System integration of PARAMOUNT system is achieved through scalability. PARAMOUNT system is three layer architecture, would facilitate system scalability both vertically and horizontally. Horizontal system scaling is where the number of clients or users can be increased to hundreds or thousands without significant impact on system performance. Vertical scaling is where the system can be moved to a larger and powerful platform or the number of servers can be increased. All the services can be made available to different mobile platforms by writing a program to the client without any changes to the server side.

6.3 Organization Domain

According to [31], the value network for location based services includes many actors like mobile devices or hardware manufacturers, communication network, content and data providers, application developers, application platform providers, service providers, positioning component and the user. Government agencies and standard organization's play supporting role in the value chain. Value chain is very long and relations have to be maintained properly in order to realize LBS.

Positioning component is responsible for calculating the position. The determination of position is achieved through mobile operator or through GPS device. LBS provider holds key position and offers service for realizing LBS. The service provider has the user profile, the location data and multimedia content and the current location data for each mobile user. The service provider offers number of different services to the user and is responsible for service request processing for example, calculation of position, finding a route and searching yellow pages.

Content and data providers are responsible for offering geographical and information data. Service providers will usually not store and maintain all the information which can be requested by users. Therefore geographic base data and location information data will be usually requested from the maintaining authority for instance mapping agencies or business and industry partners for example yellow pages and traffic companies.

The application platform providers develop the software that acts as a platform to run applications on it. Application developers are responsible for developing location based applications, which are run on the LBS platform. Communication network is responsible for transfer of data to and from the mobile terminal and service providers. Finally hardware manufacturers are the people who do handsets for the users. The applications developed must be compatible with the mobile devices, include the big players like Nokia, Samsung and LG. The actors responsible for the value network are depicted in the following Figure 6.10.

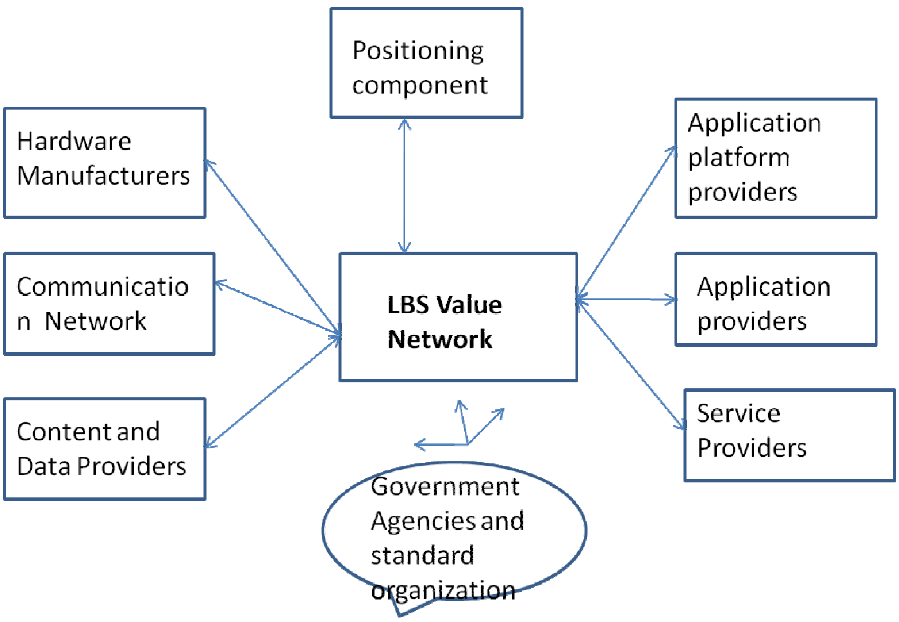

***Figure 6.10**. Value chain for realizing LBS (Adapted from [31])*

The main actors involved in realizing PARAMOUNT service and forming a value network are the handset manufactures, network operators, service providers, application providers, data providers, and end-users. The smart phone basis hardware set to run tour guide application on it. Data providers include dominant companies or open source maps communities. The tourist information should be provided to the PARAMOUNT service, this can be achieved with the contract agreements with the tourist office and related institutions for the generation\acquisition of the tourist information. For using

PARAMOUNT services, the user needs to have access to mobile network provided by network operators. Some operators in Alps include T_D1 for Germany, Tele.ring for Austria, and sfr for France. Hobby clubs is the place where people can know about these services. The source of revenue is through advertisers who advertise about their offerings on the tour guide. PARAMOUNT is the service provider for end-users. The actors in the value network should co-operate to make the service successful. The roles played by the actors should be well managed for a good service.

In value network the hardware manufacturers can be any of them who can provide smart phone with an integrated GPS module in it, making the network open to all the hardware manufacturers.The network providers can also vary, who provide the coverage in the mountainous regions, making the network open to the network operators. Figure 6.11. shows the actors involved in realizing the value network for PARAMOUNT services.

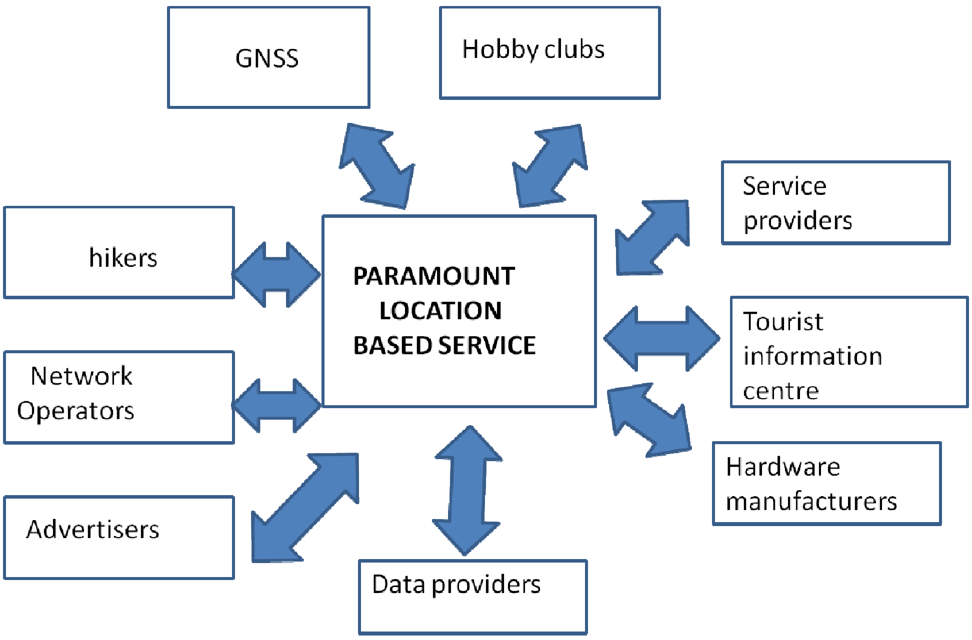

Figure 6.11. *Value network for realizing PARAMOUNT Services (Adapted from [26])*

6.4 Finance Domain

Costs for subscribing to the service should be affordable. Various pricing strategies should be used in order to attract users for using other services. And prices can be charged for per usage charge, monthly charge, six months charge, one year contract or life time contract, with various discount options.

The various cost sources for instance include software development and maintenance, marketing, server upgrading, data acquisition and data evaluation costs. Each actor in the value network or chain should make the contributions to share the costs among them. Infrastructure such as GSM network and related bandwidth costs during beta testing of services will be borne by the service providers. Hardware manufacturers, who are interested in this service, will invest in initial prototype manufacture. GIS database will bear the costs which are related to GIS data. Tourist information, part of the value chain will help in promoting the service during beta phase.

If the prototype works as expected and provides quality service to the end users, the revenues can also be shared among the actors responsible for the success and bearing the costs of this service. The main revenue sources are the advertisers, who advertise on the tour guide application to users about their offerings, the end users who use this service.

7. CONCLUSIONS

Wide adoption of mobile devices such as smart phones, combined with positioning technologies, is providing a strong foundation for innovative location based services which are interesting and useful in everyday activities of people from all walks of life and making up a good business proposition. LBS are also being proved very useful in areas such as medicine, safety and security. Important components of LBS are users, positioning component which determines the co-ordinates latitude, longitude and altitude of a geographic location using different positioning techniques such as satellite positioning, network positioning and hybrid positioning, telecommunication network which helps in sharing and transmitting data between components and GIS data which maps geographic coordinates to a place. Location based services are classified into “person oriented” and “device oriented services” both of which can be achieved using two approaches namely “push” type and “pull” type. LBS, as a system, involve many actors such as users, service providers, hardware suppliers, software vendors, content providers and data providers. And, to make all these actors work together in synergy, standardization is very important which triggered the creation of bodies such as OMA, IETF OGC and so forth.

With great opportunity comes the risks; use of LBS raised concerns over the collection and use of personal information by unauthorized parties or by the service providers itself. This potential threat gave birth to different privacy frameworks for creating location based services and prompted EU Commission to recognize this in its directive called Privacy and Electronic Communications.

And not the least, for a service or a product to be profitable and sustainable in long term, it requires a viable business model. This thesis looked at a conceptual business model called STOF (Service, Technology, Organization and Finance) which helps in evaluating and introducing new services, specifically mobile services, into the market successfully by identifying critical design issues (CDI’s) of the business. This model is applied in evaluating a demo project called PARAMOUNT, sponsored by European Commission, which provides location based services in mountaineering.

The critical design issues from service, technology, organization and finance domains are identified in PARAMOUNT project which makes it a viable business if commercialized. On the other hand workshops with hikers and SAR teams have been conducted and the direct involvement of SAR teams in the project ensured that the user requirements on the system are inline with situations met in emergency scenarios as well as the user and system requirements for the whole system are verified by professionals involved in hiking, which provides acceptable quality of service. A successful LBS service should be able to provide values not only to end users, but also to all players in the value network. PARAMOUNT service offered a good value to mountaineers by supporting them with different tours under service domain and meets the technology domain requirements to provide “Intended value” of the service domain. The value proposition for this project is to provide appropriate information for mountain hikers and wanderers with integration of support and control facilities for mountain rescue services to make the outdoor recreation as fun. Value network which consists of different actors are also identified, which includes handset manufactures, network operators, service providers, application providers, data providers, hikers, advertisers, tourist information centre and hobby clubs. Regarding the SAFETOUR functionality a transfer to applications for other public areas, such as fire brigade and police is also considered.

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APPENDIX 1: Obfuscation Techniques

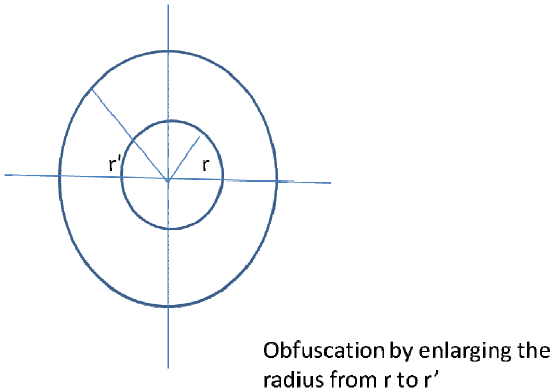

Figure 4.8. *Obfuscation by enlarging the radius (Adapted from [3])*

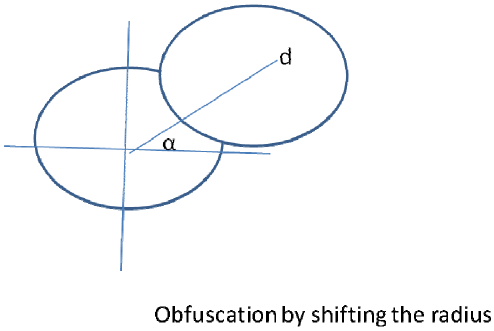

Figure 4.9. *Obfuscation by shifting the centre (Adapted from [3])*

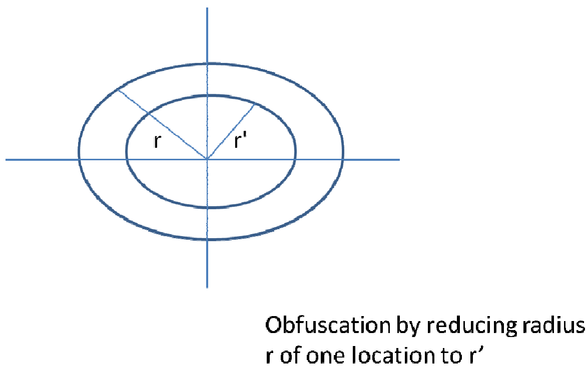

Figure 4.10. *Obfuscation by reducing the radius (Adapted from [3])*